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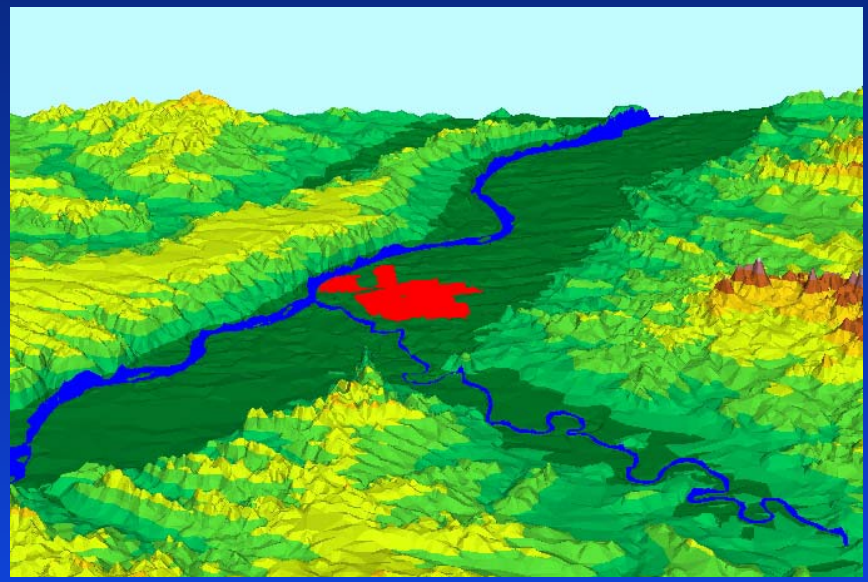
OTHA – Omaha Tools for Hydrologic Analysis



William Doan, P.E.

Hydraulic Engineer, U.S. Army Corps of Engineers,
Omaha District

bill.p.doan@usace.army.mil

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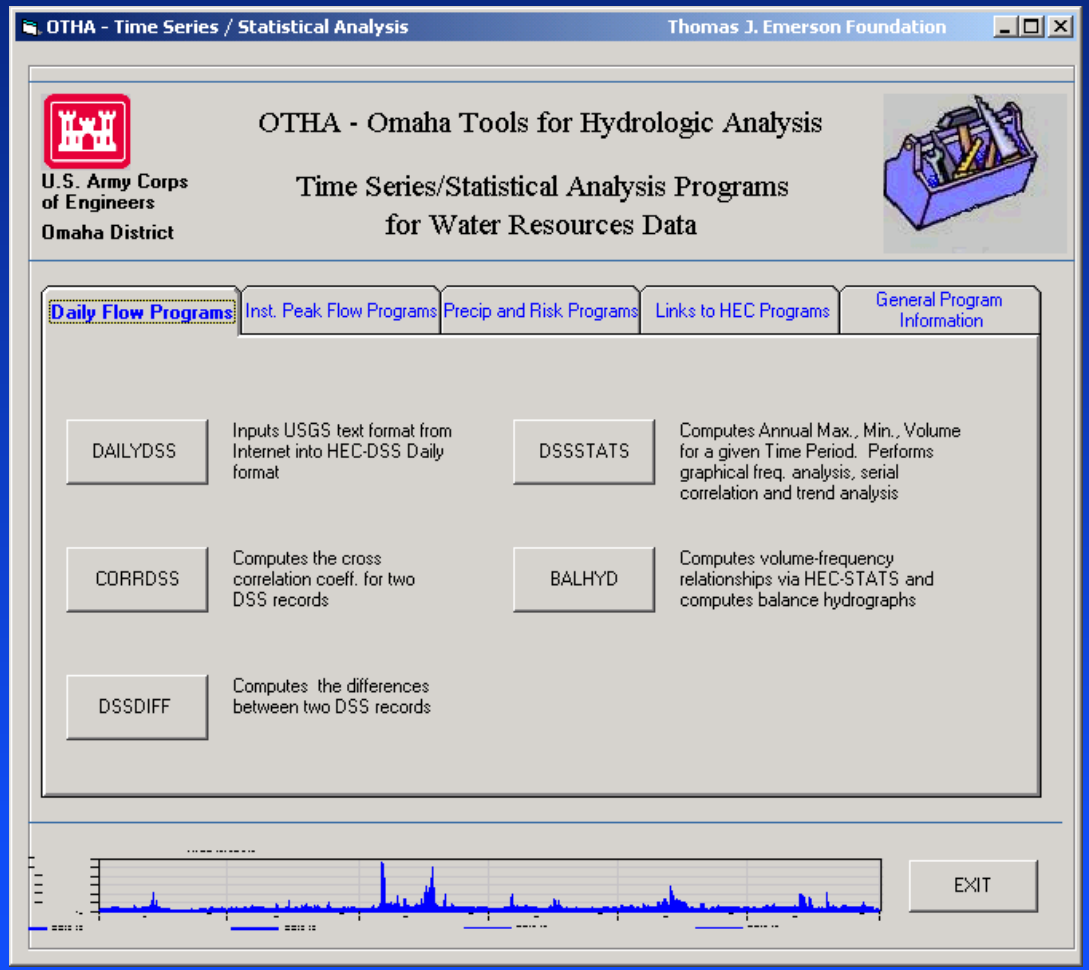
Time-Series/Statistical Analysis Programs for Water Resources



-What is it?

-Collection of programs/routines written in Omaha District on an "as-needed" basis

- "Advanced" statistical routines to use in conjunction with HEC-FFA, STATS

- Small, simple, stand-alone routines

- FORTRAN engines/VB GUI Interfaces

- Toolbox for time-series and statistical analyses.

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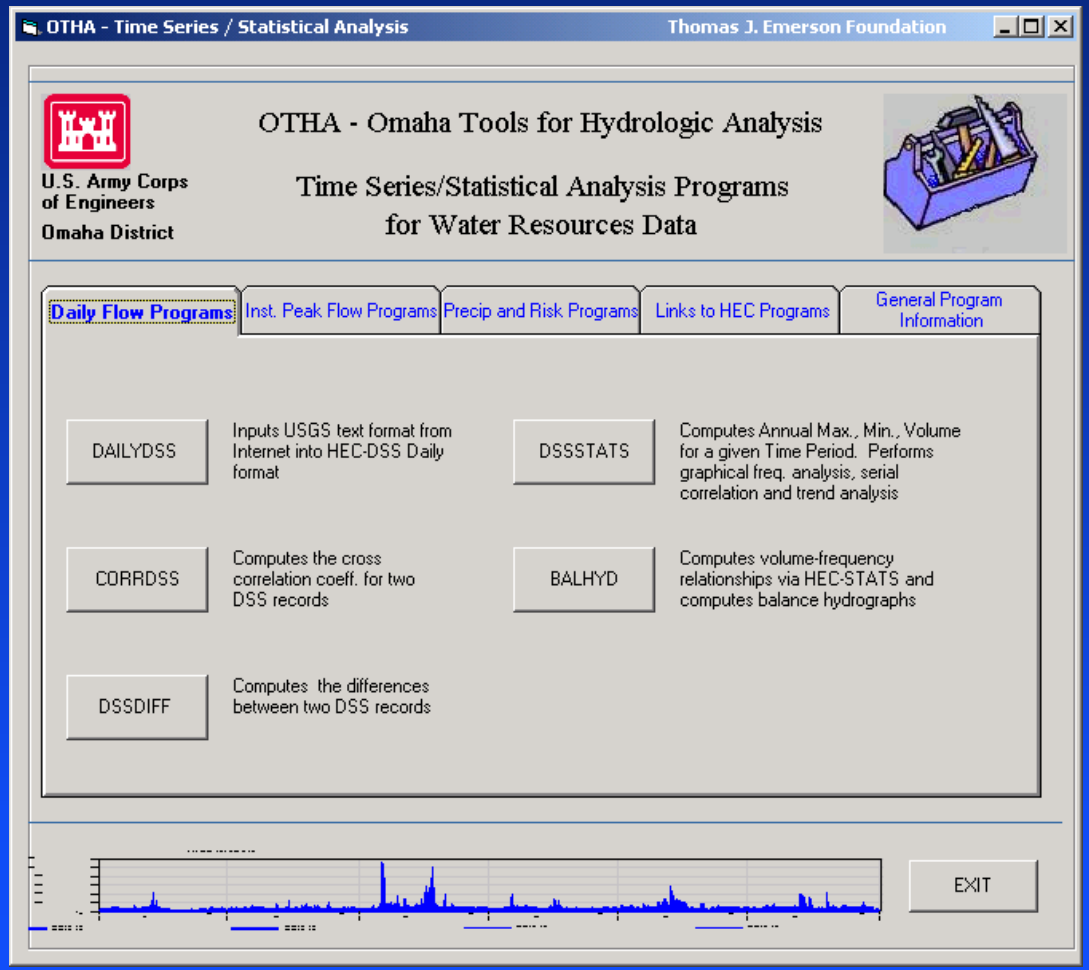

- SPECIFIC MODELLING GOALS:

- Direct access to data via the Internet

- Convert data to standardized format

  (DSS - Daily Flow and FFA Input - Peak Flow)

- Provide for monthly, seasonal, or annual analysis

- Provide a common “look or feel” for all routines

- Provide a useful tool for working engineers

- Quick “tour” of program ….

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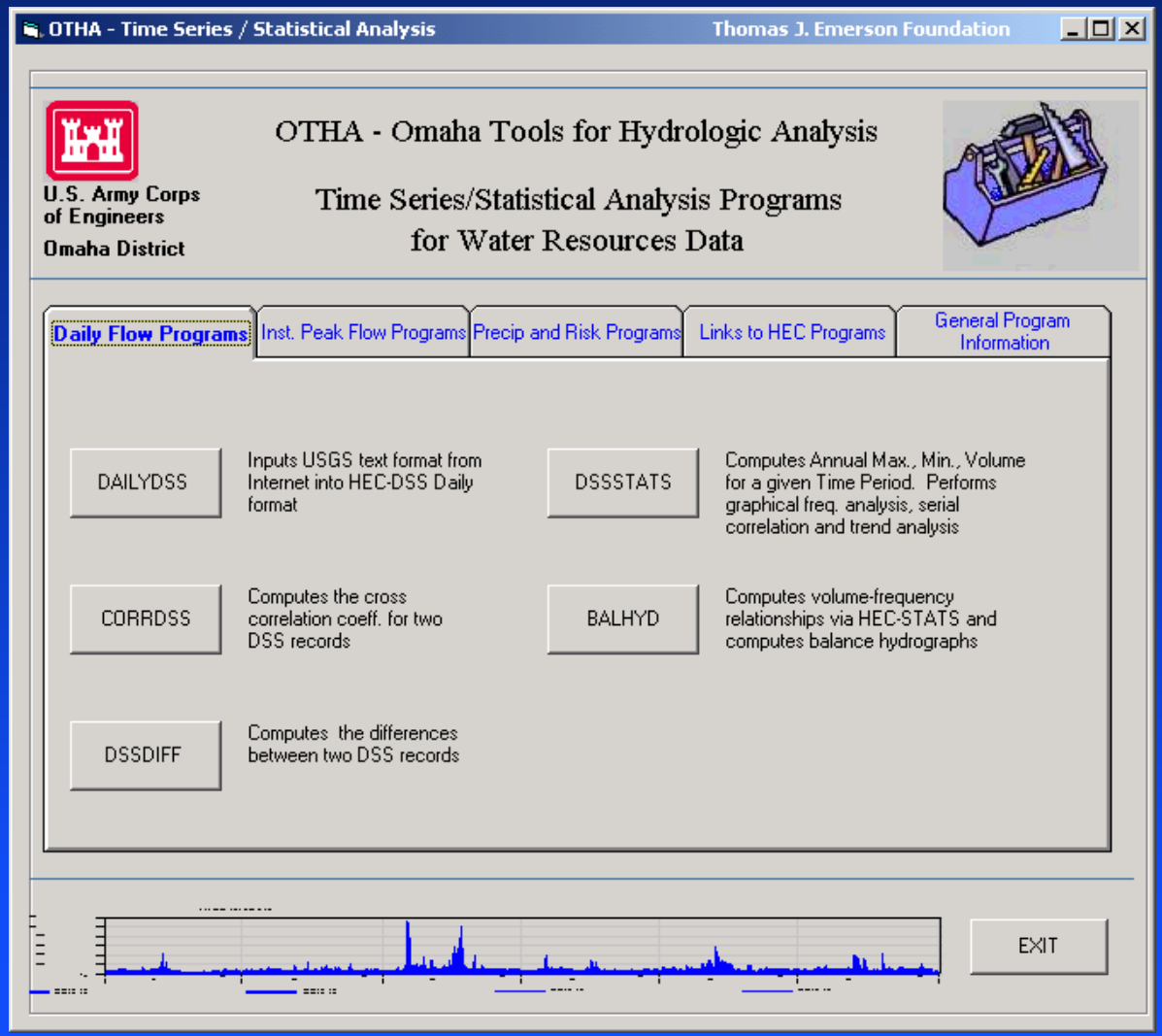

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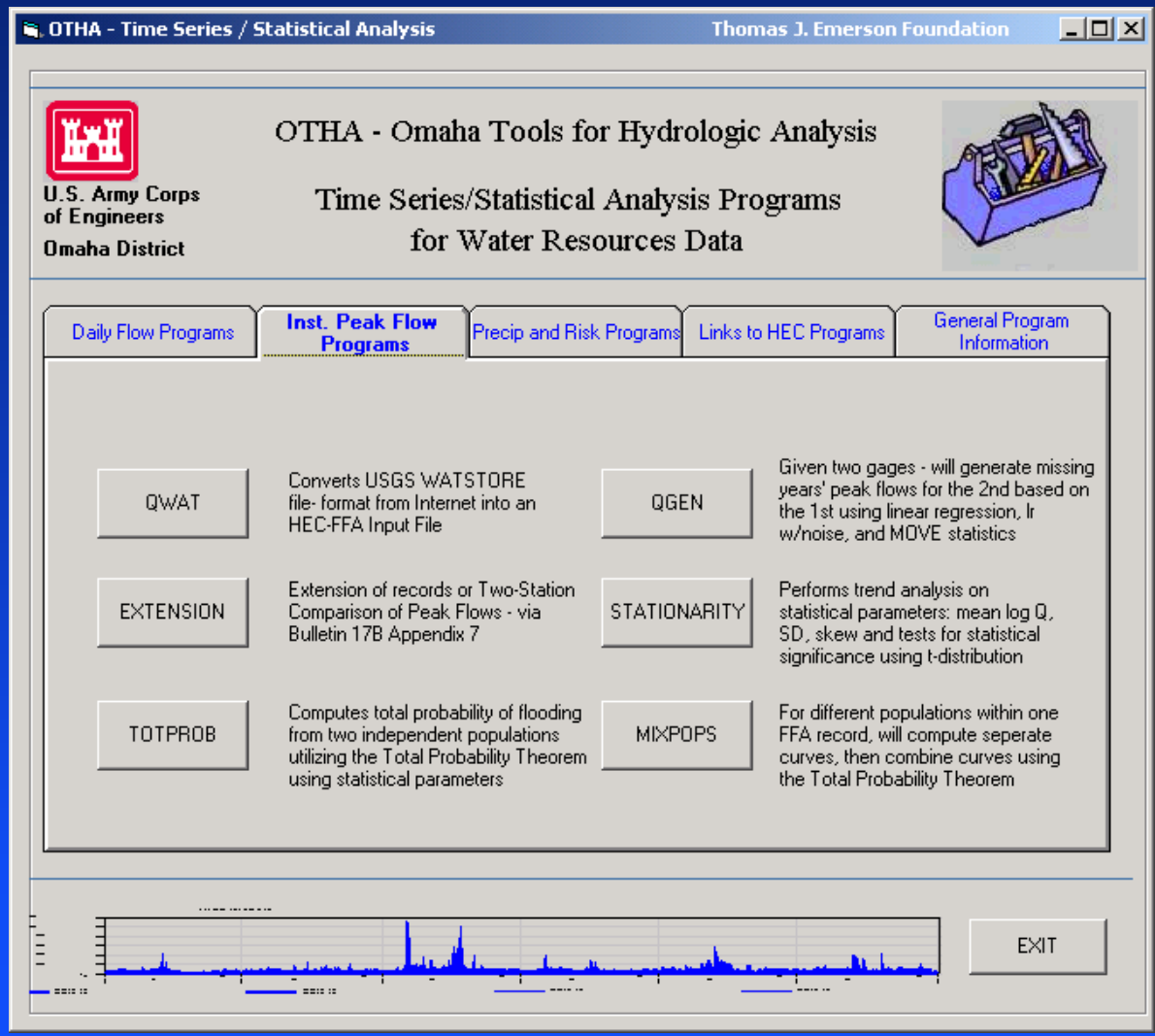

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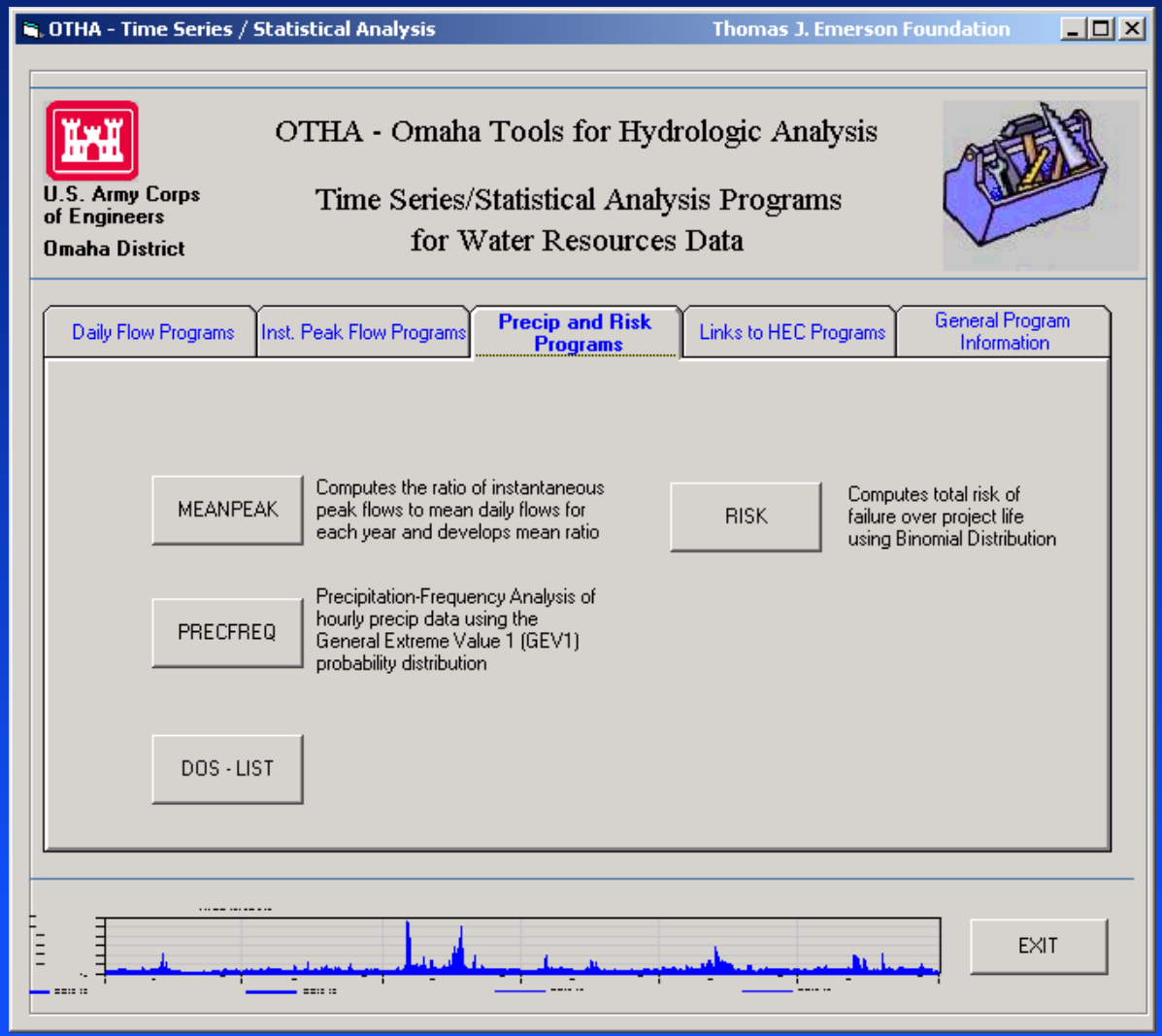

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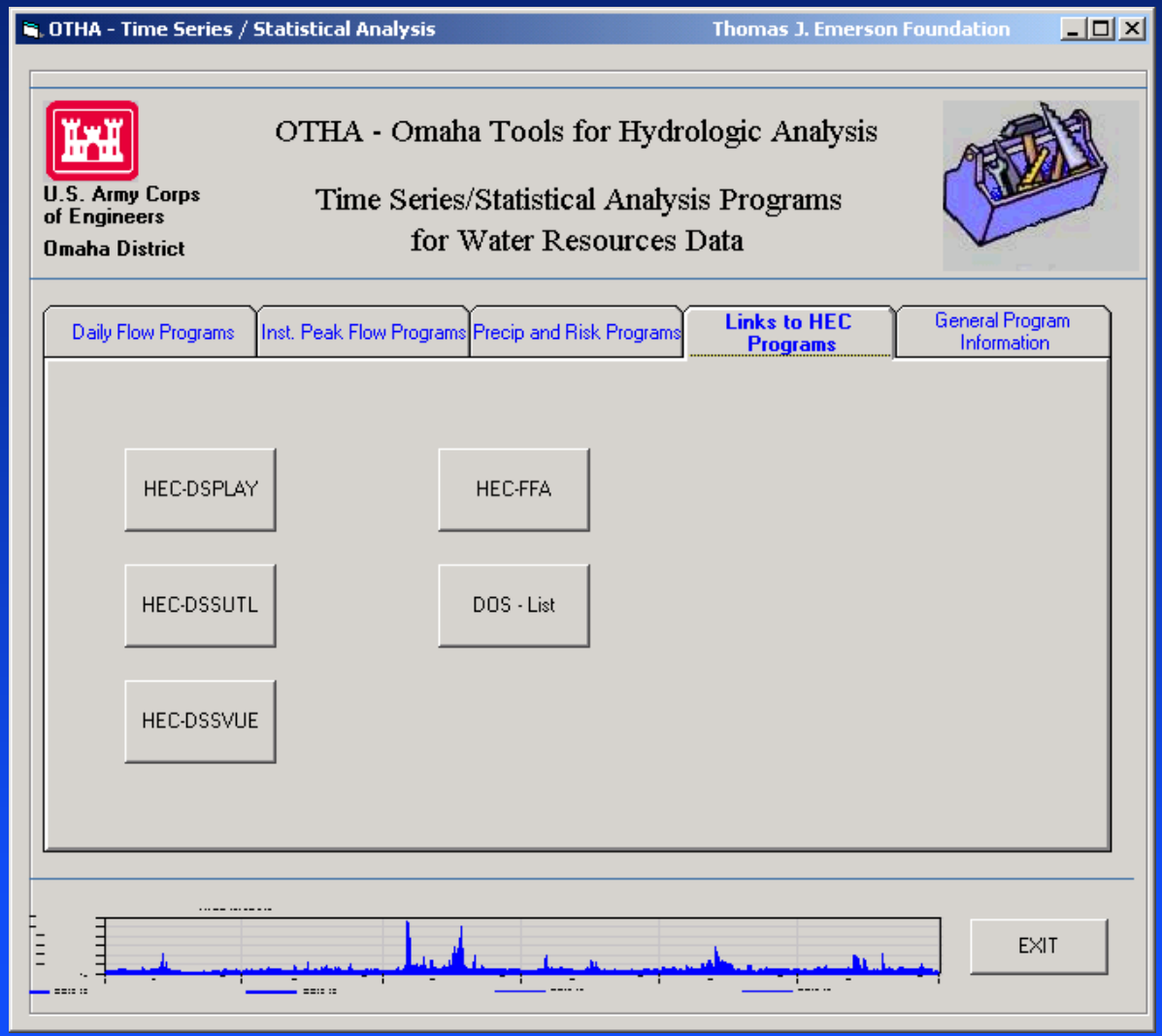

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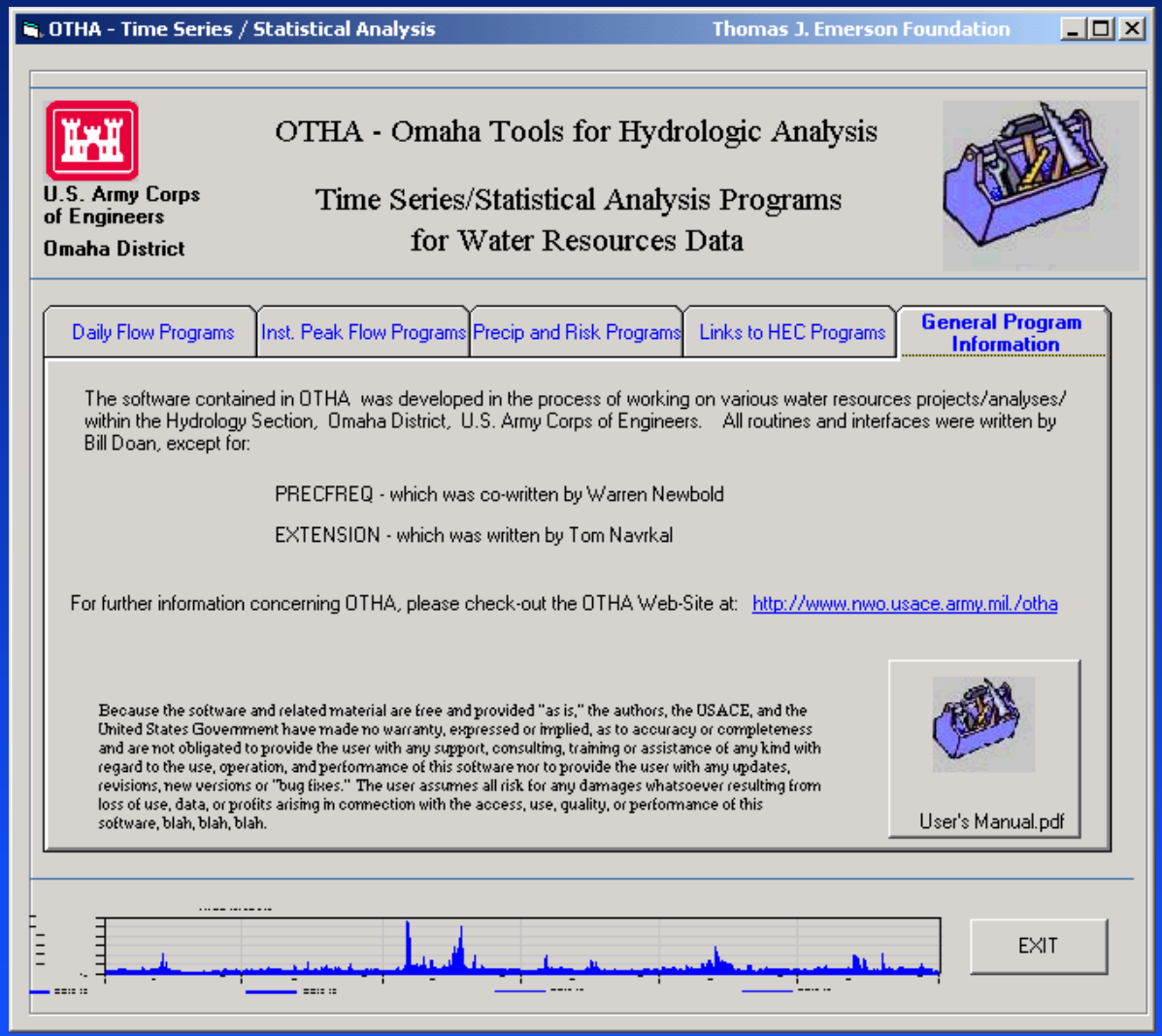

Routines…

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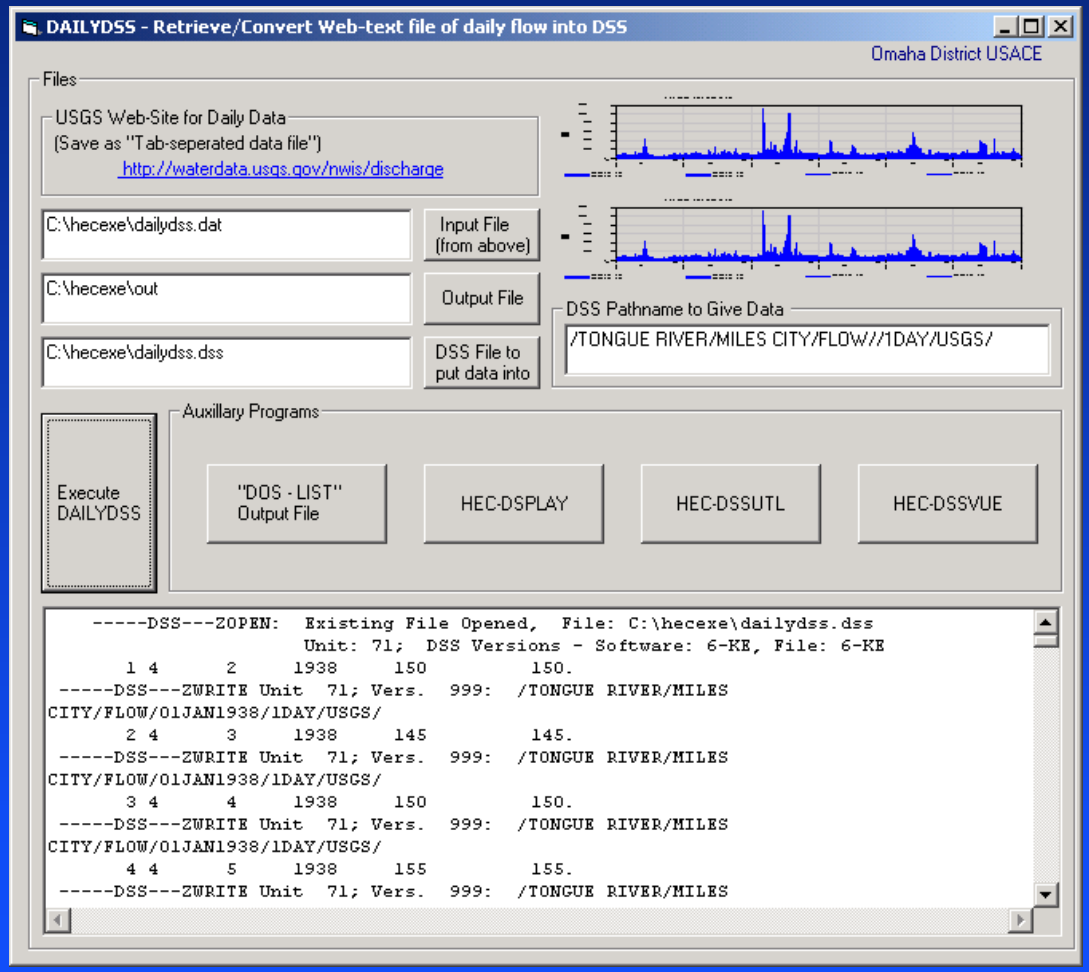
DAILYDSS



- Retrieves/Converts USGS *Daily* flow data
- Links to USGS Daily Flow Site – using default browser
- Once find gage – download data (Save as "Tab-separated data file")
- Give DSS filename and DSS Pathname
- Converts to DSS
- Also works on USGS "RECENT" data.

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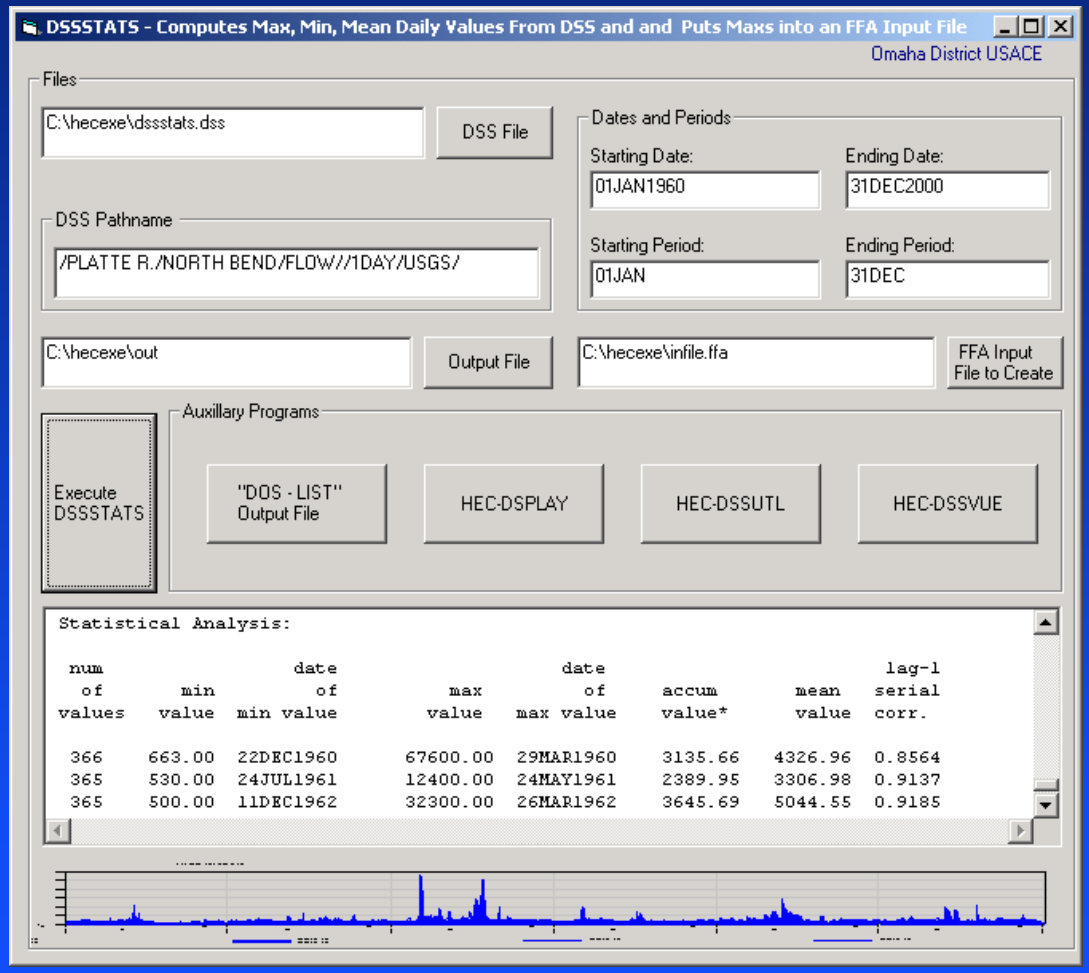
DSSSTATS



- Annual statistical summary of daily flows
- Min, max, means, volumes
- Monthly, seasonal, or annual basis
- Graphical Freq. Analysis
- Analytical Freq. Analysis
- Writes max flows out to FFA Input File
- Trend Analysis/Statistical Tests
- Example:

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DSSSTATS - Example

Annual Period:

Statistical Analysis:

num of values	min value	date of min value	max value	date of max value	accum value*	mean value	lag-1 serial corr.
366	663.00	22DEC1960	67600.00	29MAR1960	3135.66	4326.96	0.8564
365	530.00	24JUL1961	12400.00	24MAY1961	2389.95	3306.98	0.9137
365	500.00	11DEC1962	32300.00	26MAR1962	3645.69	5044.55	0.9185
365	315.00	26JUL1963	14700.00	24JUN1963	2249.23	3112.27	0.9152
366	520.00	30JUL1964	21200.00	17JUN1964	2431.29	3354.98	0.7797
365	633.00	17AUG1965	26600.00	26MAY1965	3809.28	5270.90	0.8465

Monthly Period:

Statistical Analysis:

num of values	min value	date of min value	max value	date of max value	accum value*	mean value	lag-1 serial corr.
31	3230.00	30MAY1960	20300.00	07MAY1960	410.89	6694.19	0.8533
31	2850.00	03MAY1961	12400.00	24MAY1961	307.73	5013.55	0.9918
31	1700.00	15MAY1962	13400.00	20MAY1962	274.69	4475.16	0.8511
31	1880.00	28MAY1963	3860.00	02MAY1963	173.76	2830.97	0.7609
31	1460.00	25MAY1964	12700.00	27MAY1964	270.29	4403.55	0.5513
31	2760.00	17MAY1965	26600.00	26MAY1965	433.22	7058.06	0.9303

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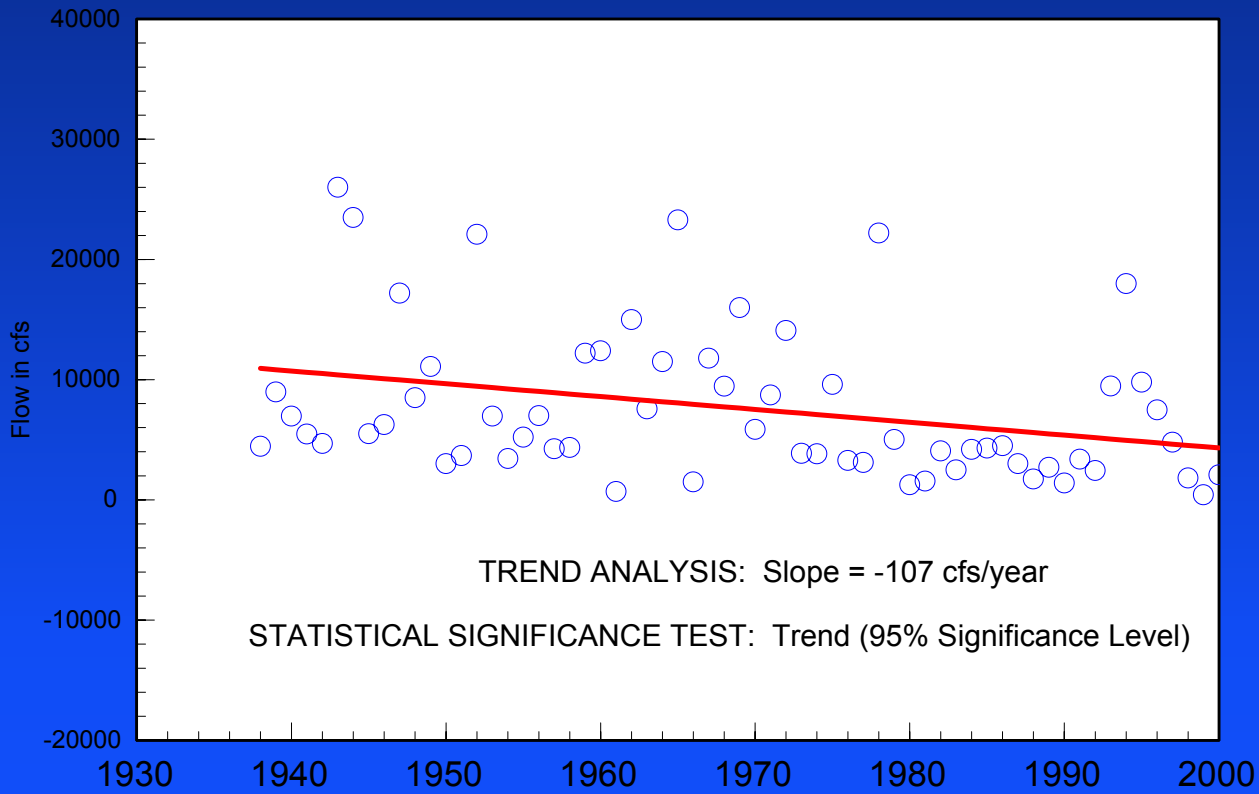
DSSSTATS – Example (cont'd)

Trend Analysis:

Powder R. near Locate, MT
Annual Maximum Mean Daily Flows



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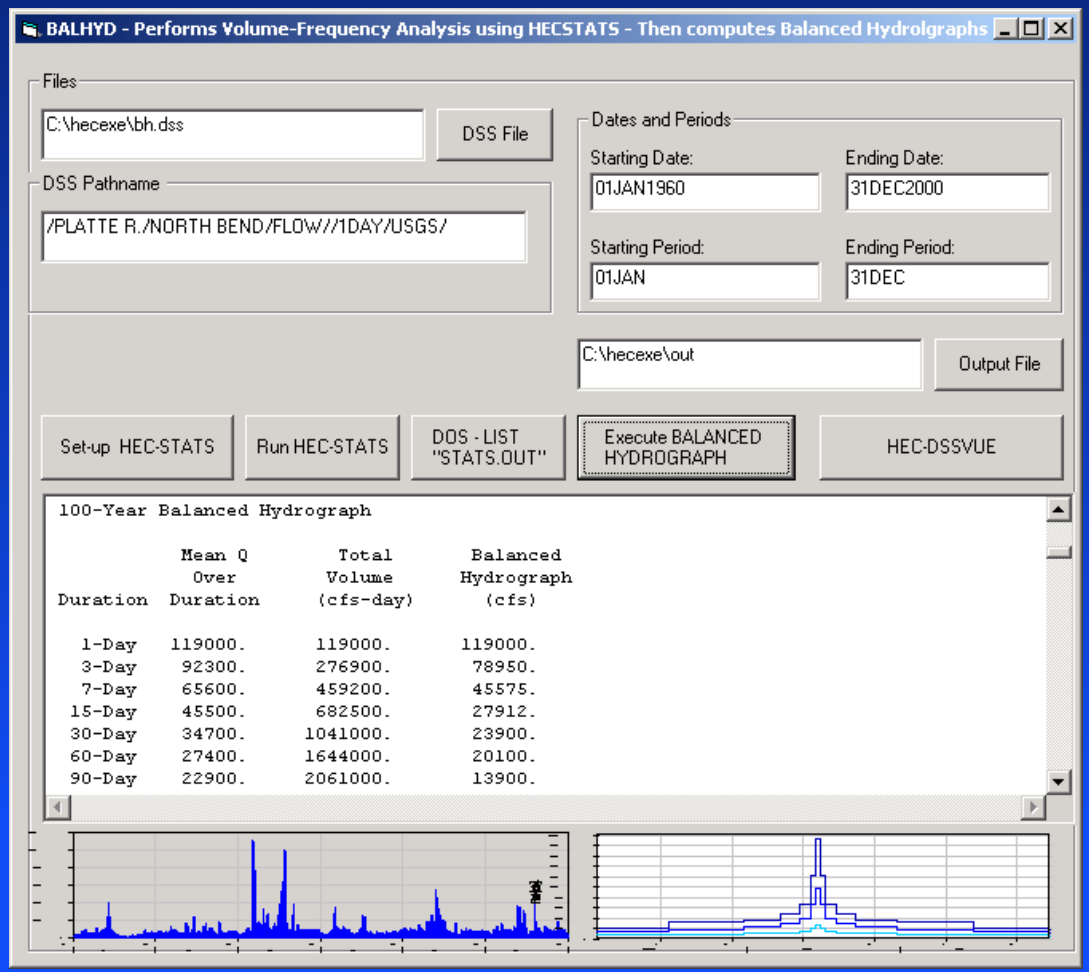
BALHYD



- Serves as GUI for HEC-STATS
- Runs STATS (Vol-Freq) in “background”
- Takes STATS results and develops “Symmetrical Balanced Hydrographs”
- Writes 10-, 25-, 50-, 100-, and 500-year BH to HEC-DSS
- F-Part Path – “100-Year BH”
- Monthly, seasonal, or annual basis
- Example:

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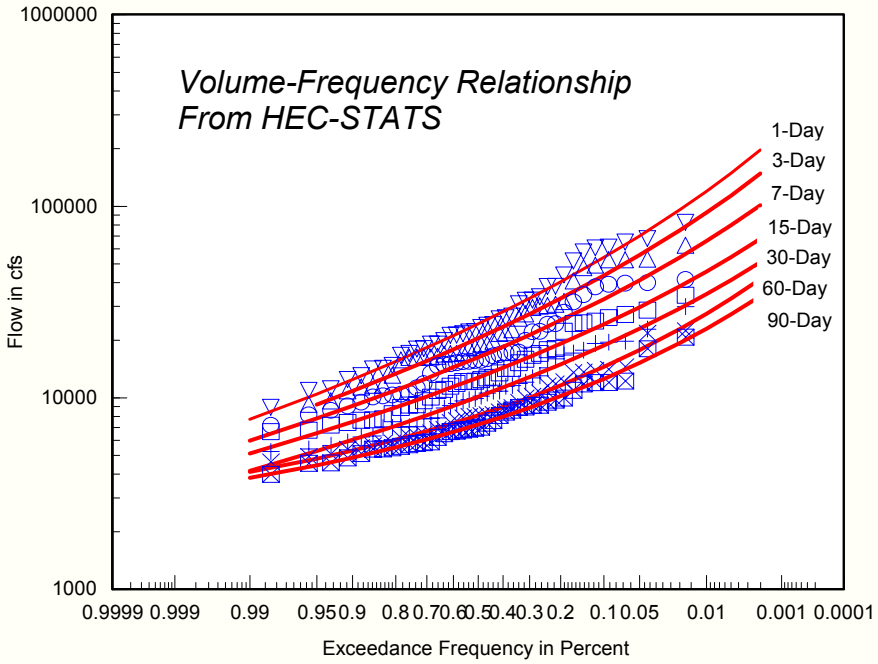
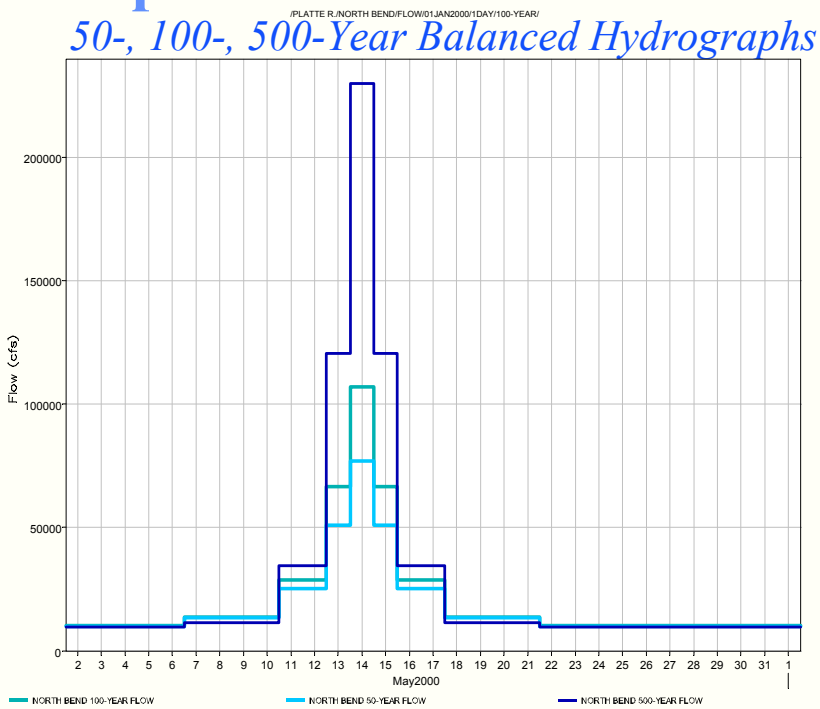
BALHYD - Example



50-, 100-, 500-Year Balanced Hydrographs



-Pretty simple – a lot of number crunching

-Used to take days, now can do in minutes.

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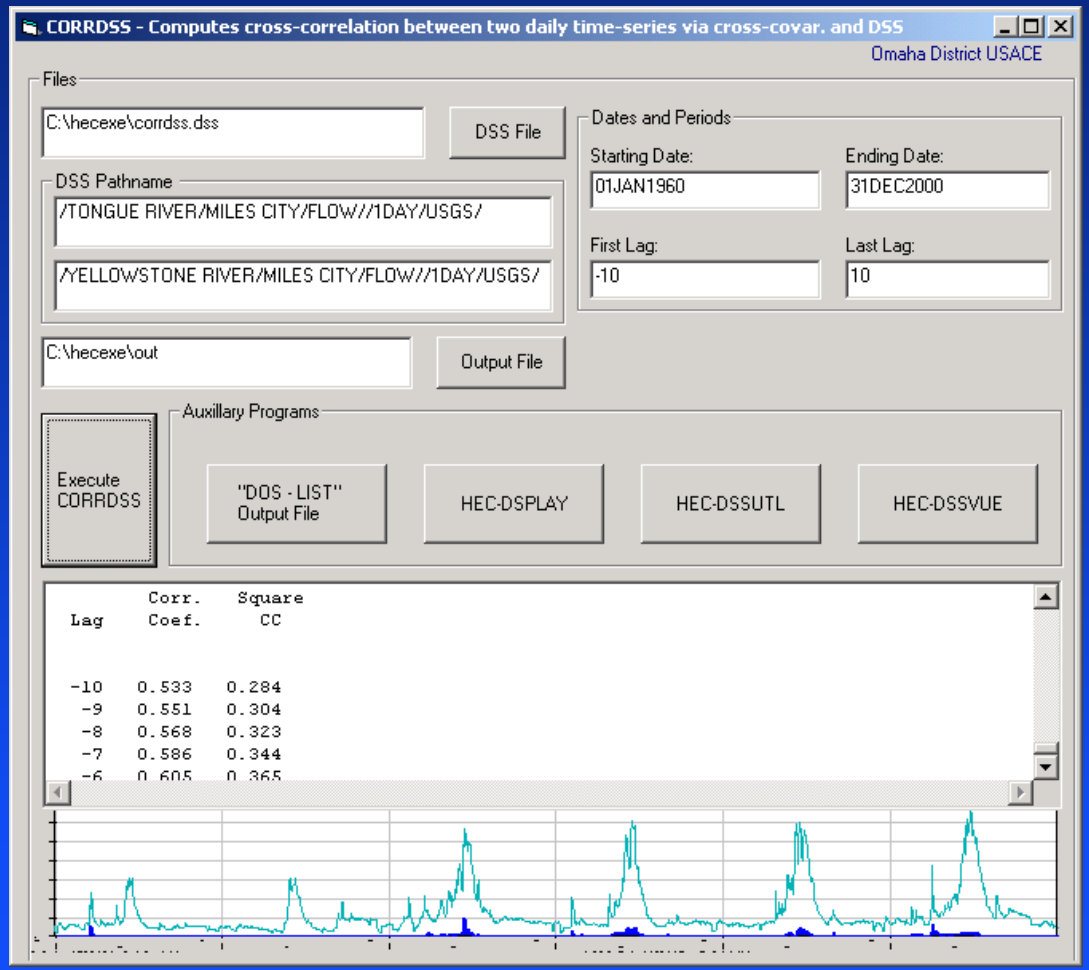
CORRDSS



-Time-Series cross-correlation using the cross covariance

$$r_k^{ij} = \frac{c_k^{ij}}{(c_o^{ii} c_o^{jj})^{1/2}}$$

$$c_k^{ij} = \left(\frac{1}{N}\right) \sum_{i=1}^{N-k} \left(y_{t+k}^{i} - y_{mean}^{i}\right)\left(y_t^{j} - y_{mean}^{j}\right)$$

-Tells prob that 2 rivers will flood concur

-Number btwn 0 and 1 indicating coincidence

-Confluences or interior drainage analyses

-Example:

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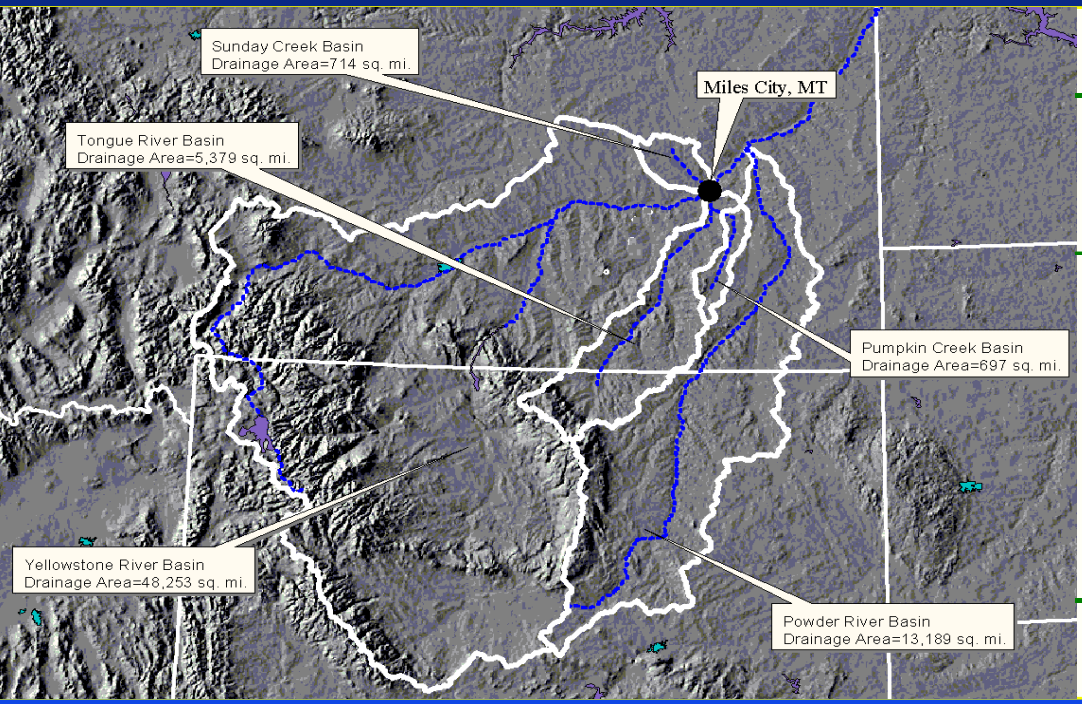
CORRDSS Example



Cross-Correlation Coefficients for Various Creeks and Rivers

	Yellowstone River	*Powder River*	*Tongue River*	*Sunday Creek*	*Pumpkin Creek*
Yellowstone	1.000	.486	.675	.213	.172
Powder	.486	1.000	.741	.470	.566
Tongue	.675	.741	1.000	.363	.408
Sunday	.213	.470	.363	1.000	.837
Pumpkin	.172	.566	.408	.837	1.000

- Hydrologically Similar Basins have higher CC
- Quantifies the relationship
- Analysis takes a few hours.

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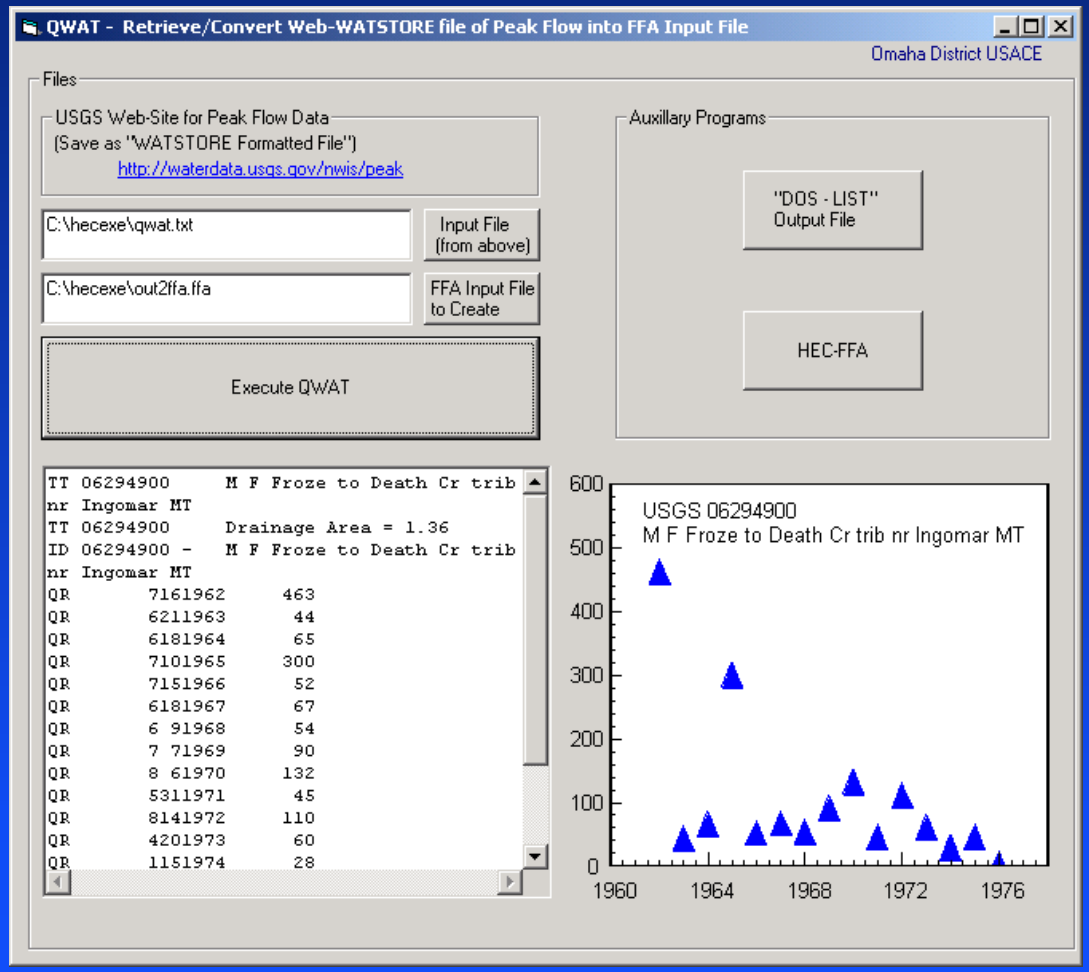
QWAT



- Retrieves/Converts USGS *Peak* Flow Data

- Links to USGS Peak Flow Site using default browser

- Once find gage – download data (WATSTORE Format)

- QWAT converts to FFA Input File (QR Cards).

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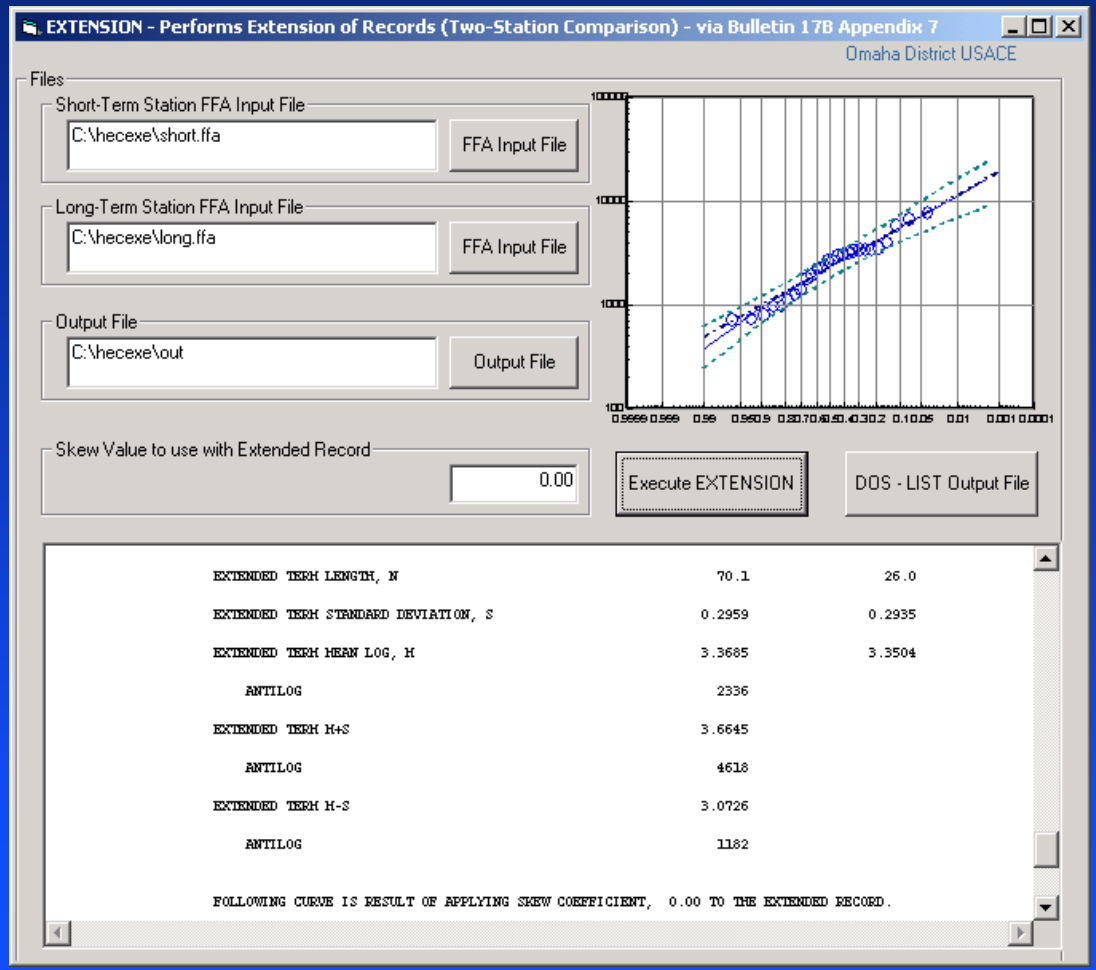
EXTENSION



- Extension of Records or Two-Station Comparison – Bulletin 17B – Appendix 7

- Adjusts mean log Q and stand deviation of short-term station based on long-term station

- Can use inputted skew value for freq-curve (technically this method is for zero skews)

-Example:

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EXTENSION (Example)

Statistical Properties	Short-Term Station	Long-Term Station	Extended Short-Term Station
Mean log discharge	3.3504	3.4907	3.3685
Standard deviation	0.2935	0.1904	0.2959
Years of record	29	92	70 (Equivalent)

- Modifies Statistical Parameters

- Performs Freq-Factor Equation.

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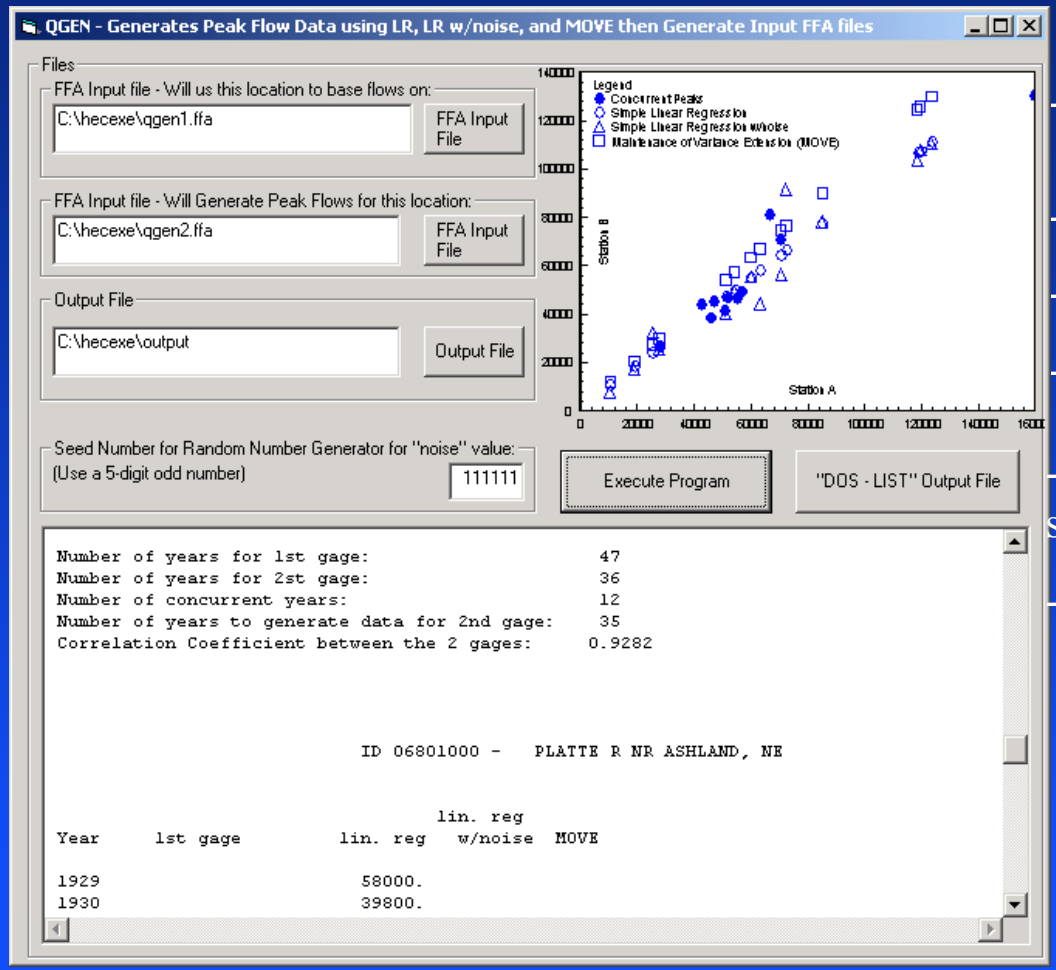
QGEN



- Synthetic generation of individual peak flows

-Simple Linear Regression with nearby gage

-Linear Regression with "noise" (normally dist.)

- Maintenance of Variance Extension (MOVE)

-Writes-out original data combined with synthetic data to three FFA input files:

-Outlr.ffa Outlrwn.ffa Outmove.ffa

- Example:

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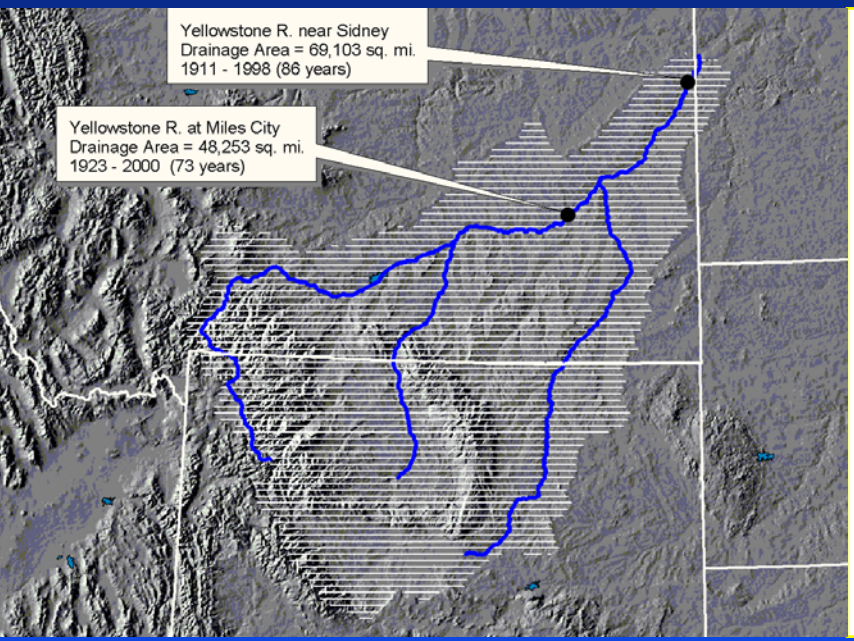
QGEN (Example)



Yellowstone River Application for Linear Regression, Linear Regression with noise, and MOVE

	Yellowstone River
Number of Years for Long-Term Gage (Sidney)	86
Number of Years for Short-Term Gage (Miles City)	73
Number of Concurrent Years between Gages	69
Number of Years to Generate Data	17
Correlation Coefficient	.89

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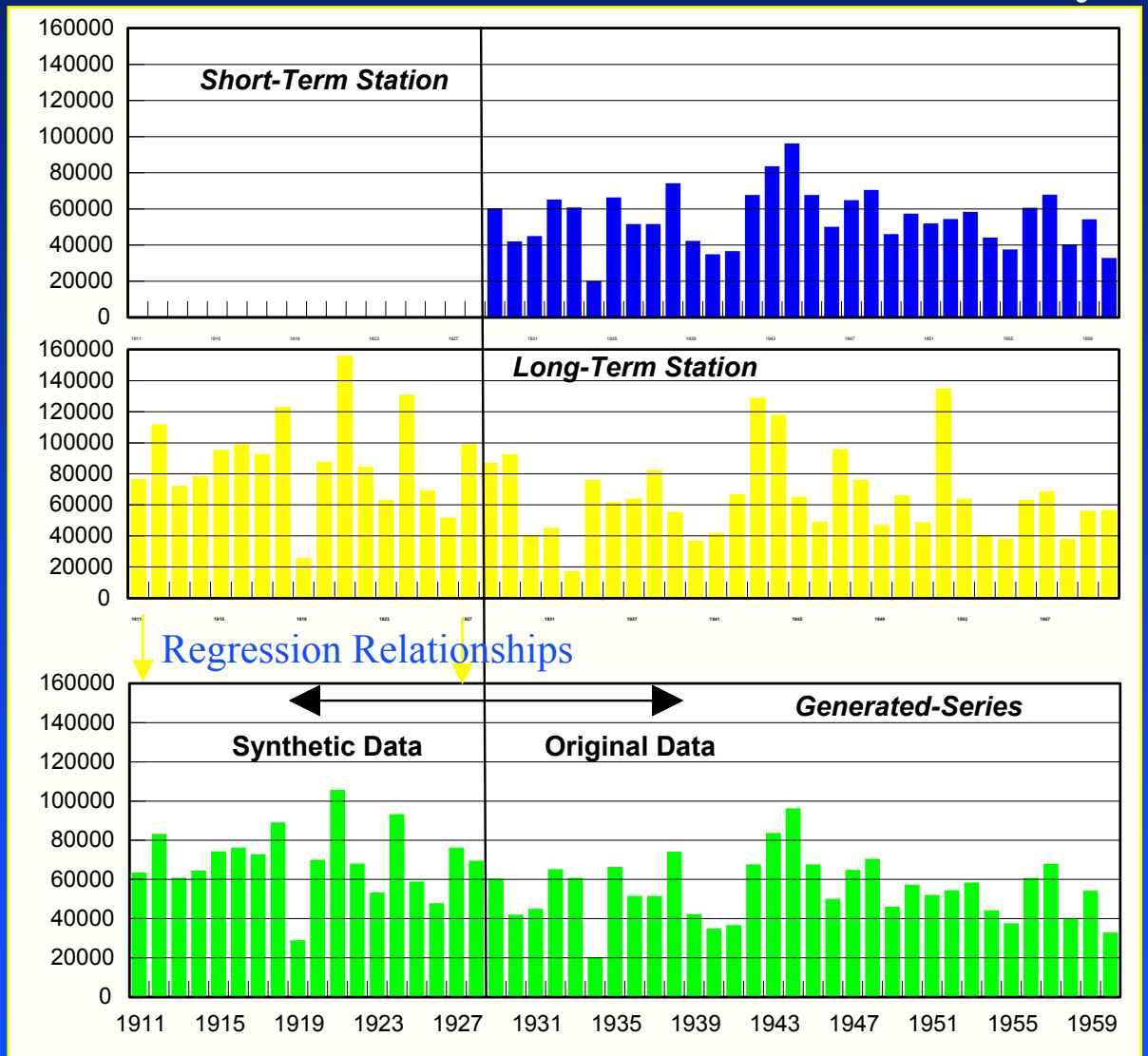
QGEN (Example)



-Setups 3 FFA Input Files

-Run FFA.

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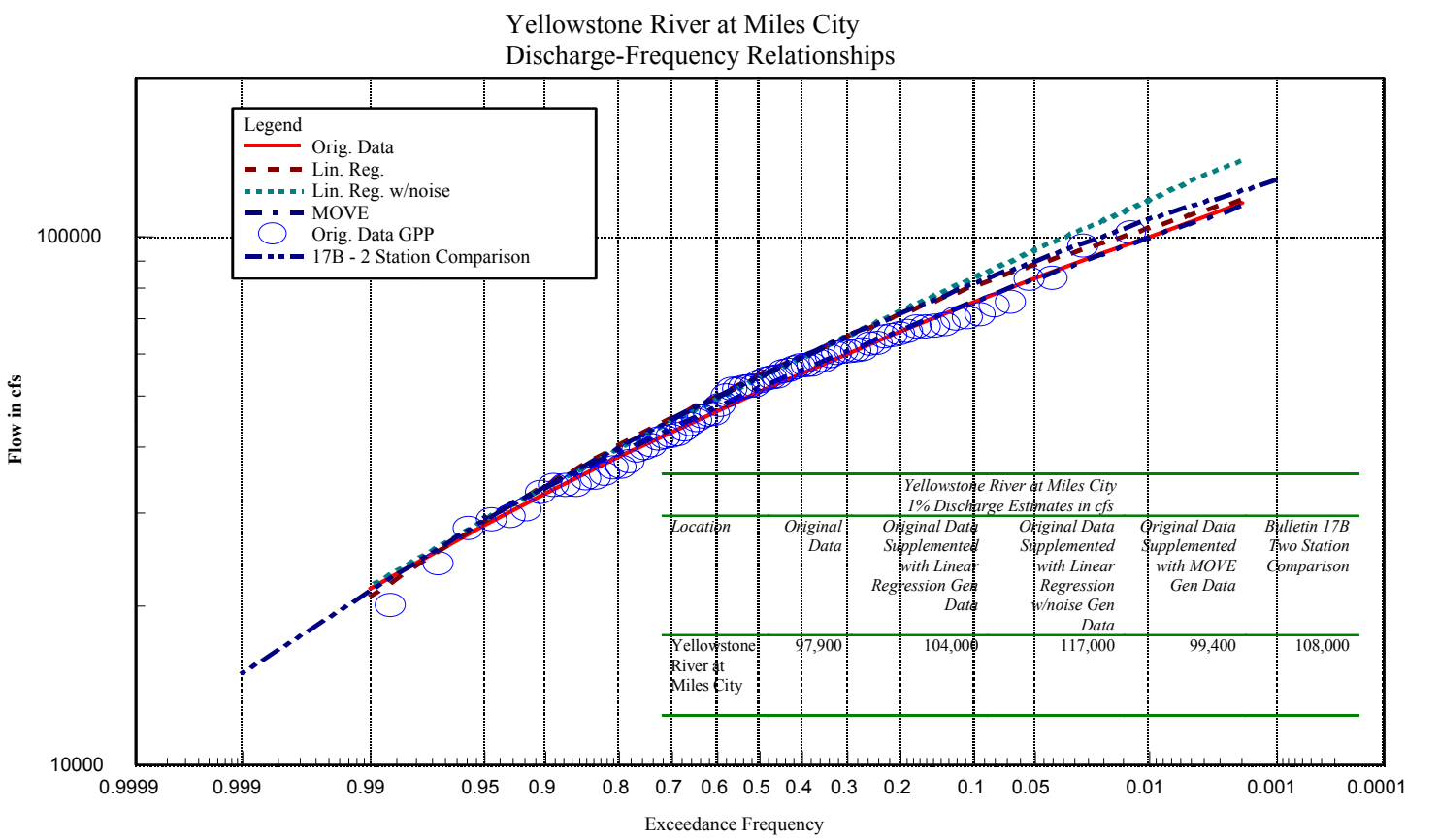
QGEN (Example)



Yellowstone River at Miles City
1% Discharge Estimates in cfs

Location	*Original Data*	*Original Data Supplemented with Linear Regression Gen Data*	*Original Data Supplemented with Linear Regression w/noise Gen Data*	*Original Data Supplemented with MOVE Gen Data*	*Bulletin 17B Two Station Comparison*
Yellowstone River at Miles City	97,900	104,000	117,000	99,400	108,000

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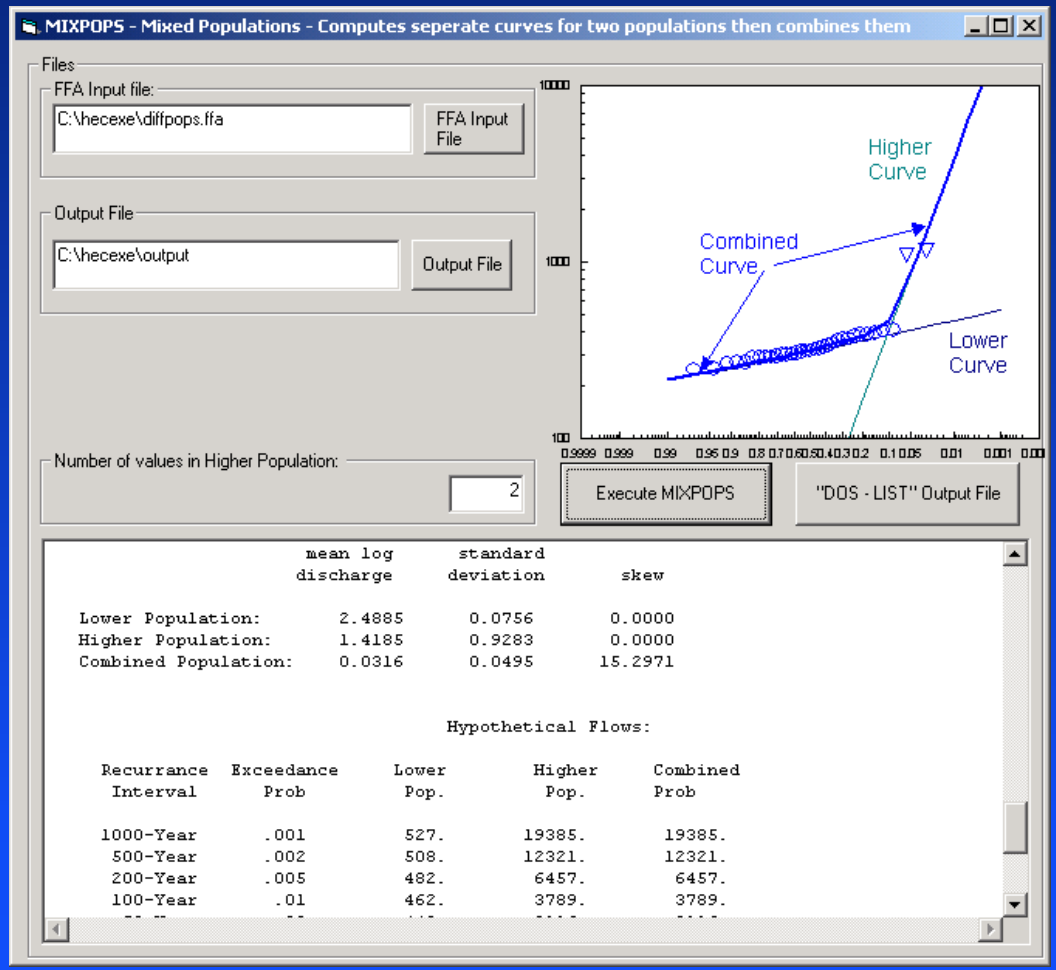
MIXPOPS



-Freq. Analysis for a gage that has 2 physically-differentiable populations – hurricane events, snowmelt runoff, etc.

-Computes separate flow-frequency curves by converting gpp to linear distances – best-fit line

-Combines two curves using the Total Probability Theorem:

$$P_{combined} = P_A + P_B - P_A P_B$$

-Example:

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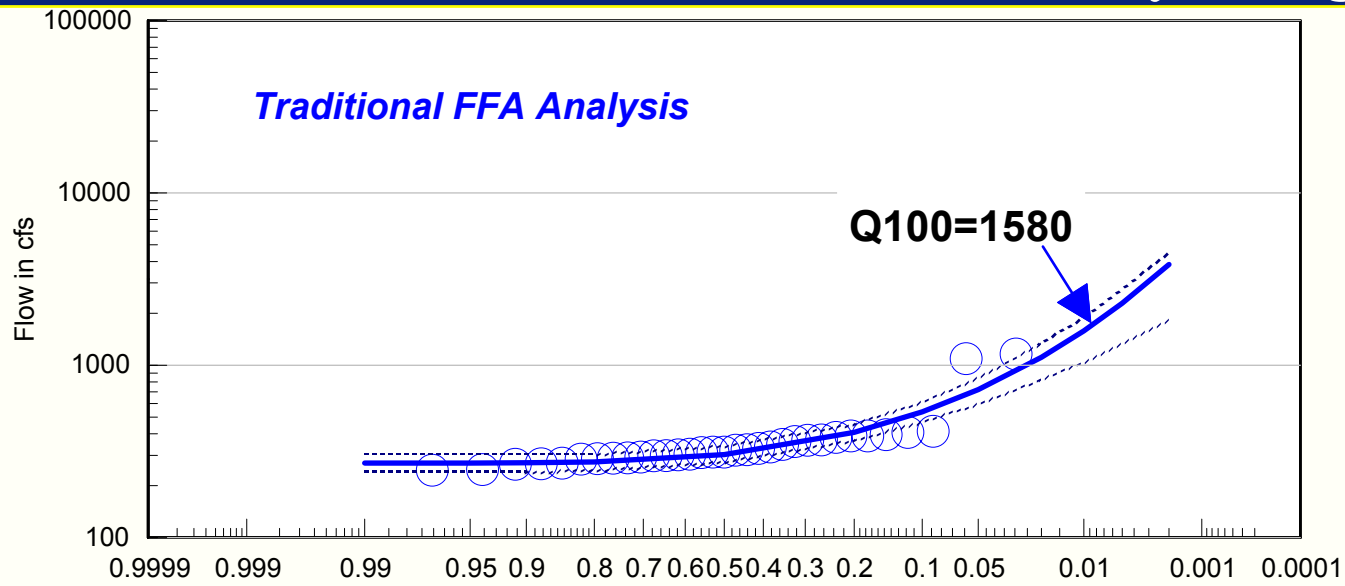

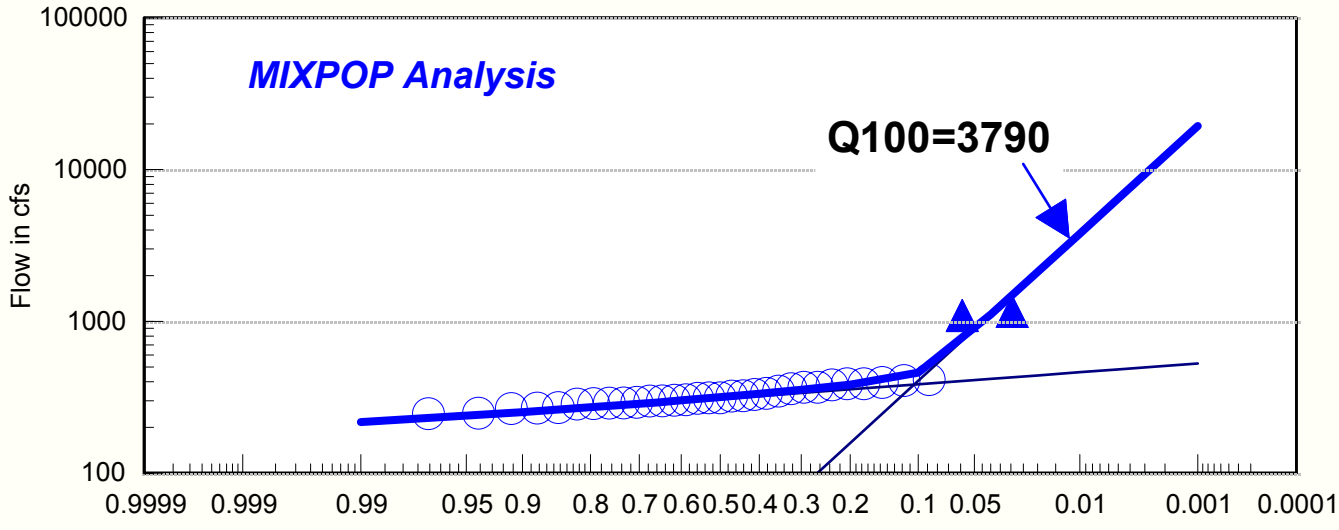

MIXPOPS (Example)

-Provides for more accurate flow-estimates.

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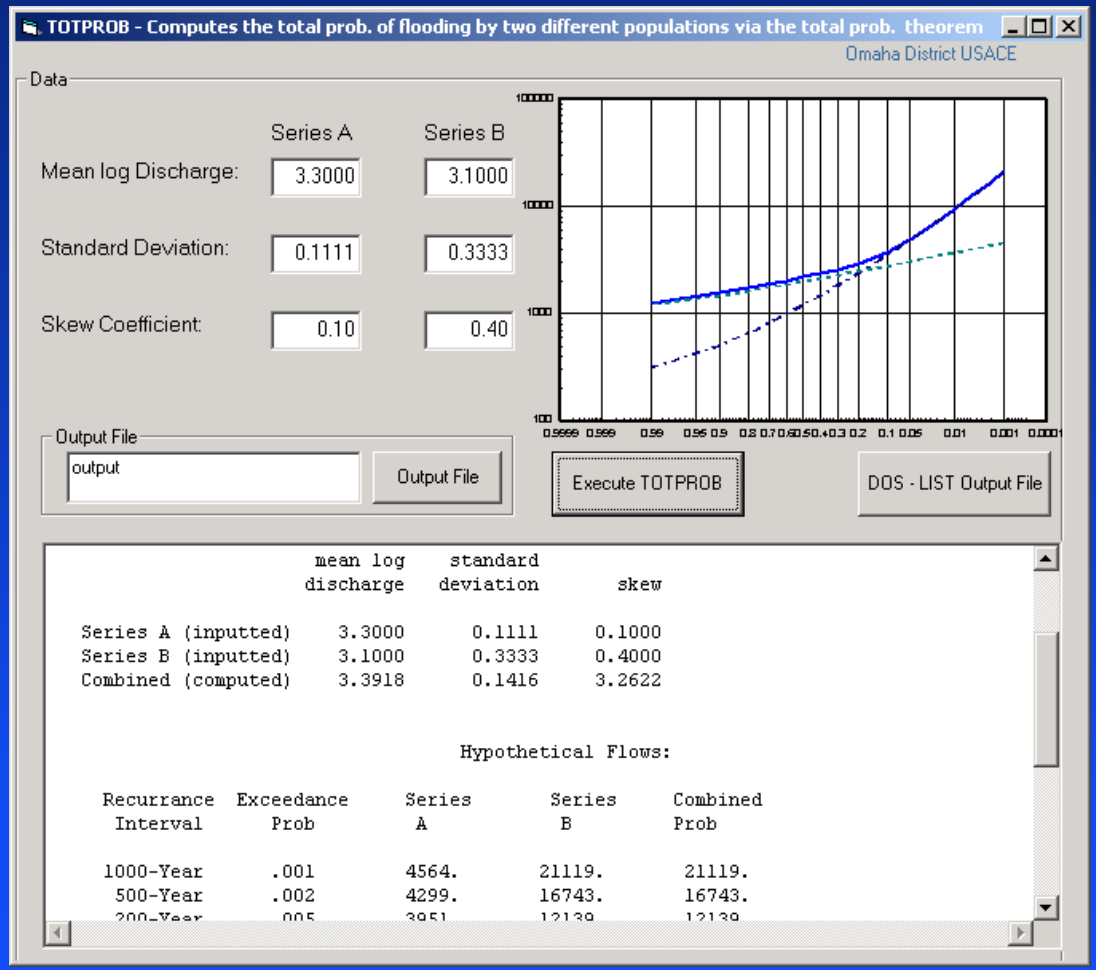
TOTPROB



-Given statistical parameters - computes LP III distribution for two populations

-Combines two curves using the Total Probability Theorem:

$$P_{combined} = P_A + P_B - P_A P_B$$

-Regional Analysis.

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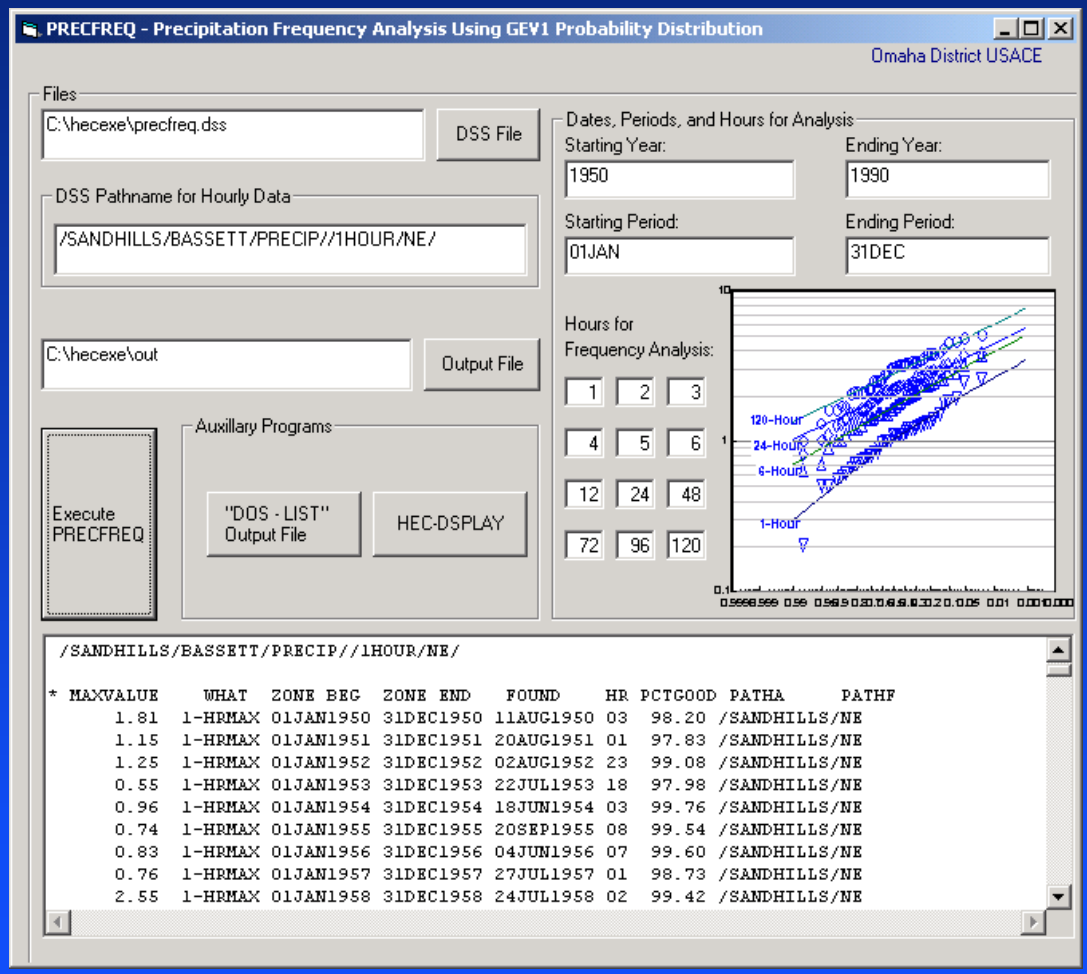
PRECFREQ



-Precipitation-frequency analysis of hourly data using the GEV-1 distribution and DSS

-Can input up to 12 different durations, (1-hour, 2-hour, 6-hour, 12-hour, etc.)

-Sorts out max "n-hour" value for each year

-Computes graphical frequency analysis and analytical solution for the GEV-1 distribution

-Monthly, seasonal, or annual basis

-Example:

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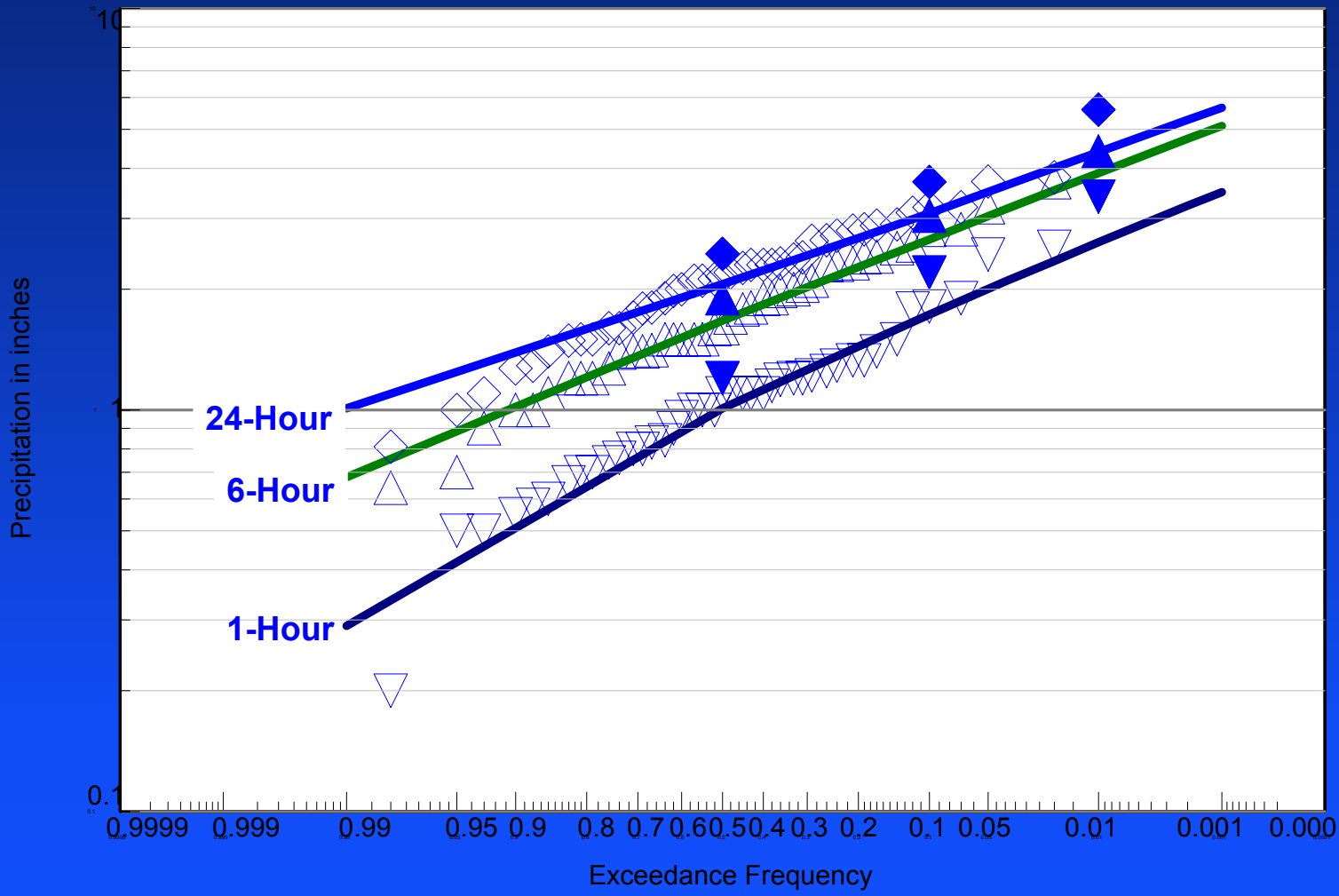
PRECFREQ



-Graphical Freq

-Analytical Freq

-Comparison/ Alternative to TP 40 or NOAA Atlas.

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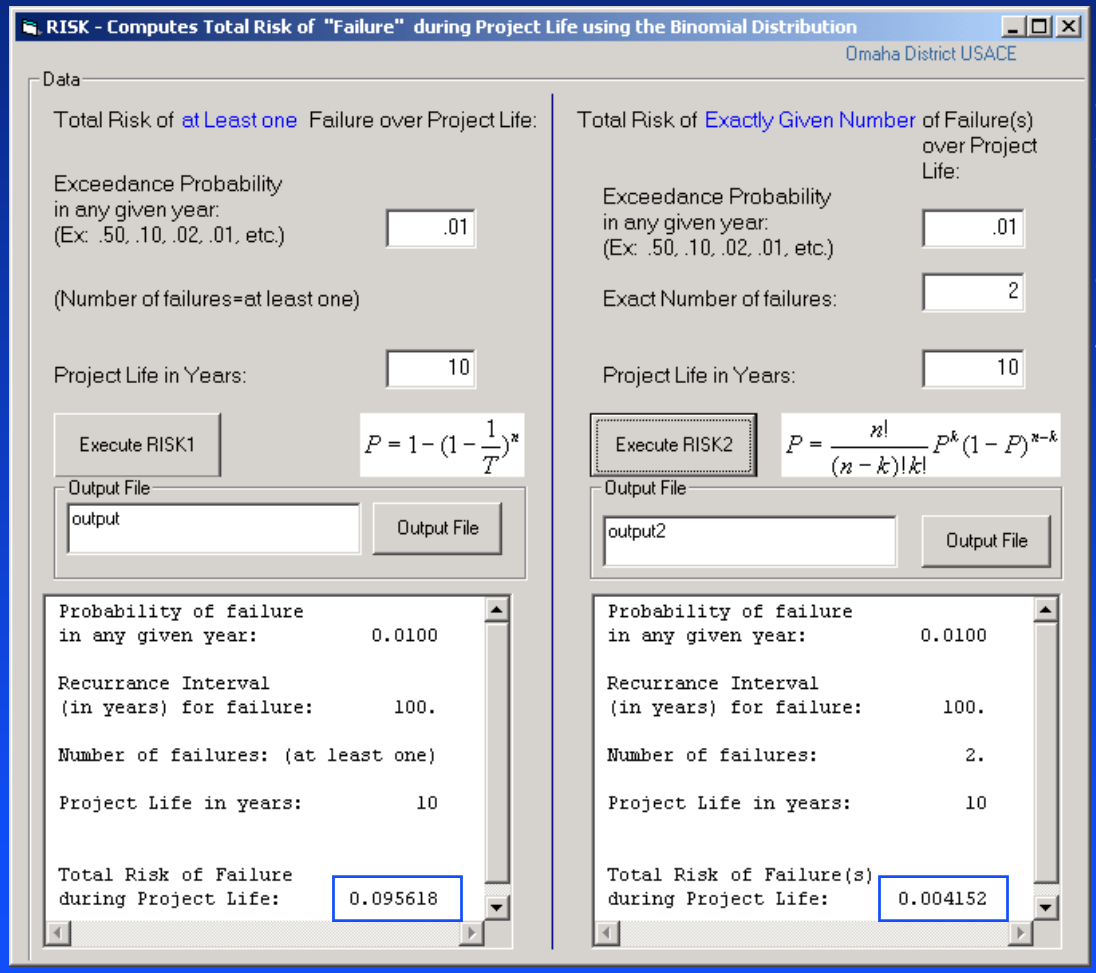
RISK



-Computes total risk of "failure" over project life using Binomial Distribution

-Computes "at least one" failure or exact given number of failures

-Example: Risk of having a 100-year flood in a ten year period is 9.6%

-Example: Risk of having 3 100-year floods in a ten year period is 0.4%.

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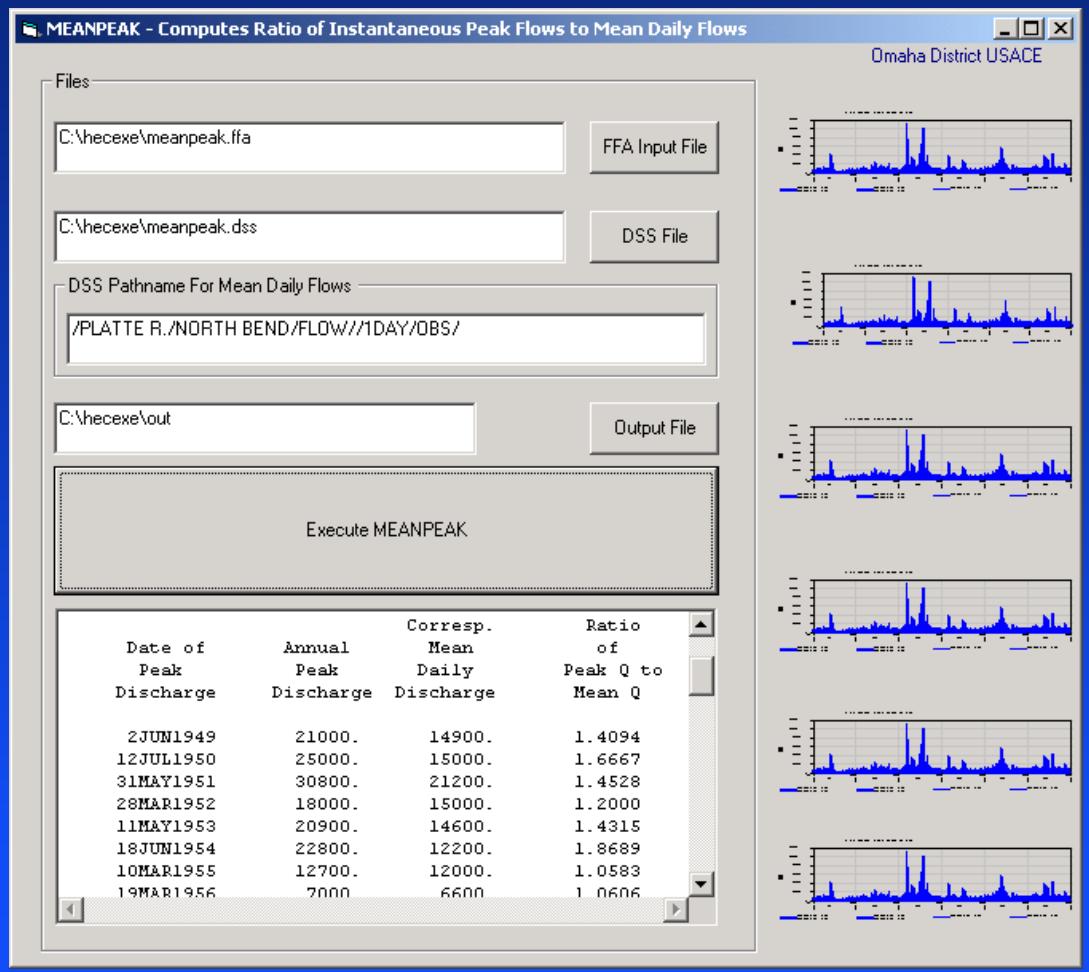
MEANPEAK



-Computes ratio of instantaneous peak flows to mean daily flows for each year

-From FFA file, determine which day peak flow occurred, then goes to DSS file to see what the corresponding mean daily flow was for that day – determines ratio

-Determines the mean annual ratio and the regression relationship between peak flow and ratio

-Example:

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MEANPEAK (Example)

/PLATTE R./NORTH BEND/FLOW//1DAY/OBS/

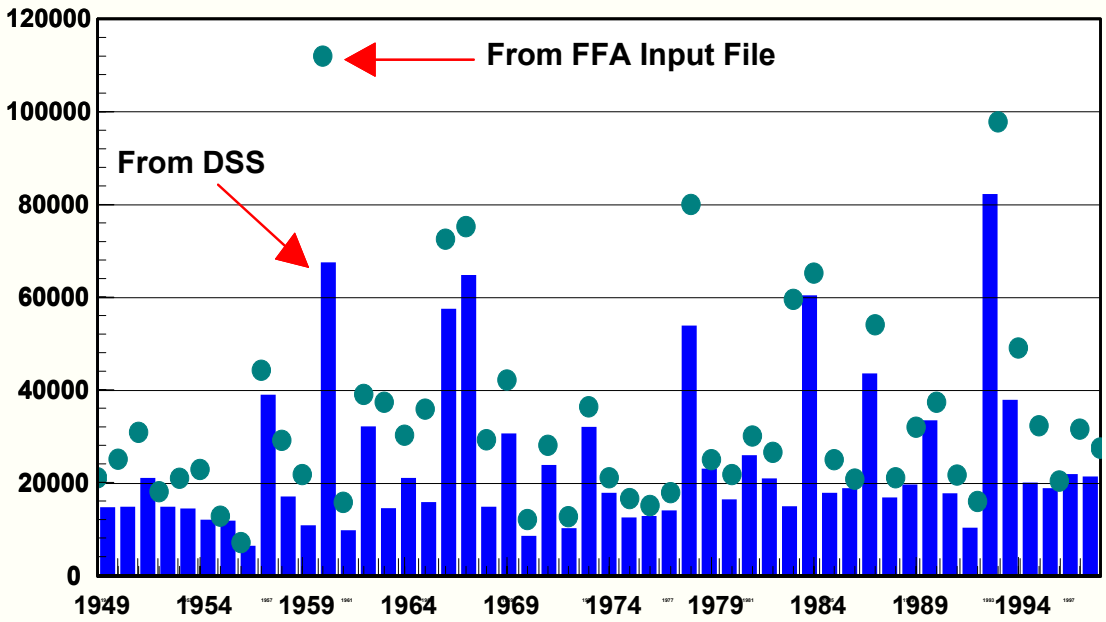
Date of Peak	Annual Peak Discharge	Corresp. Mean Daily Discharge	Ratio of Peak Q to Mean Q
2JUN1949	21000.	14900.	1.4094
12JUL1950	25000.	15000.	1.6667
31MAY1951	30800.	21200.	1.4528
28MAR1952	18000.	15000.	1.2000
11MAY1953	20900.	14600.	1.4315
18JUN1954	22800.	12200.	1.8689
10MAR1955	12700.	12000.	1.0583
19MAR1956	7000.	6600.	1.0606
17JUN1957	44200.	39100.	1.1304
.			
.			
.			
24MAR1987	54000.	43700.	1.2357
27FEB1988	21000.	17000.	1.2353
13MAR1989	31900.	19800.	1.6111
17JUN1990	37300.	33600.	1.1101
3JUN1991	21600.	17900.	1.2067
6AUG1992	15900.	10500.	1.5143
10MAR1993	97800.	82300.	1.1883
5MAR1994	49000.	38000.	1.2895
28MAY1995	32200.	20200.	1.5941
2JUN1996	20300.	19000.	1.0684
21FEB1997	31500.	22000.	1.4318
19JUN1998	27400.	21500.	1.2744

LINEAR REGRESSION ANALYSIS:

Average Mean Daily Flow= 24824.
Average Ratio of Qp to Qm= 1.43171

Y-Intercept= 1.4811220169
Slope= -0.0000031839

Qp =[1.4811220169 + -0.0000031839(Qm)] (Qm)



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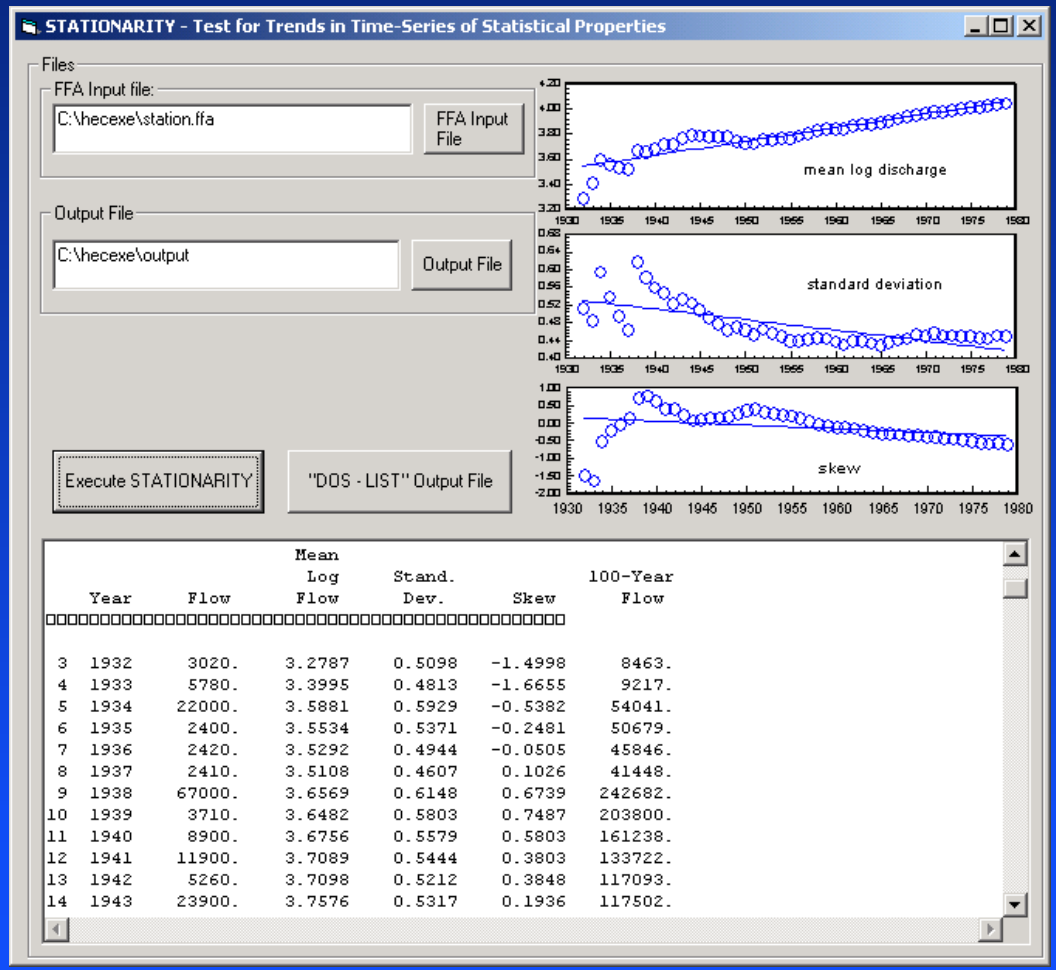
STATIONARITY



	Year	Flow	Mean Log Flow	Stand. Dev.	Skew	100-Year Flow
3	1932	3020.	3.2787	0.5098	-1.4998	8463.
4	1933	5780.	3.3995	0.4813	-1.6655	9217.
5	1934	22000.	3.5881	0.5929	-0.5382	54041.
6	1935	2400.	3.5534	0.5371	-0.2481	50679.
7	1936	2420.	3.5292	0.4944	-0.0505	45846.
8	1937	2410.	3.5108	0.4607	0.1026	41448.
9	1938	67000.	3.6569	0.6148	0.6739	242682.
10	1939	3710.	3.6482	0.5803	0.7487	203800.
11	1940	8900.	3.6756	0.5579	0.5803	161238.
12	1941	11900.	3.7089	0.5444	0.3803	133722.
13	1942	5260.	3.7098	0.5212	0.3848	117093.
14	1943	23900.	3.7576	0.5317	0.1936	117502.

-Tests for stationarity in statistical parameters

-Essentially FFA in a loop – time-series of statistical parameters

-Performs trend-analysis on stat. parameters

-Performs statistical significance using t-test (checking if slope of line is significant)

- Example:

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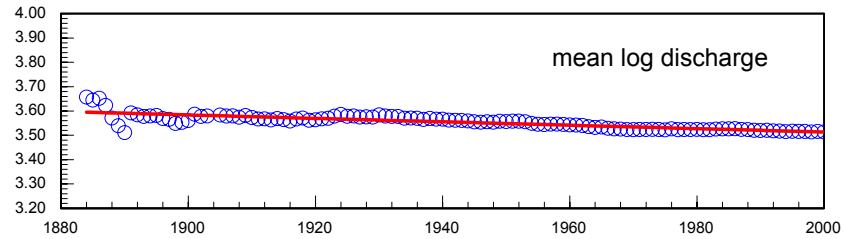
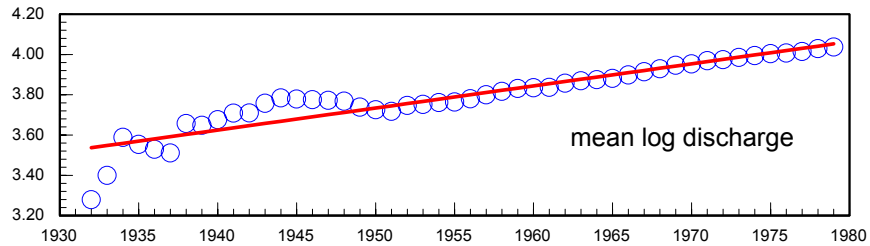
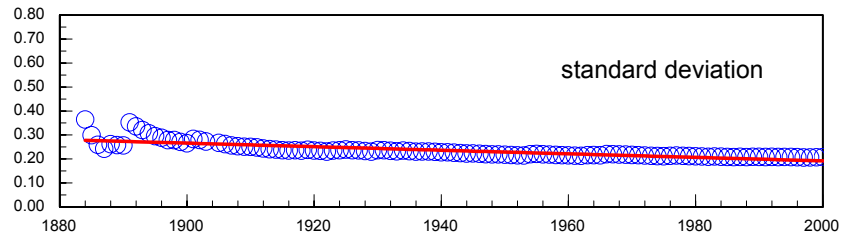
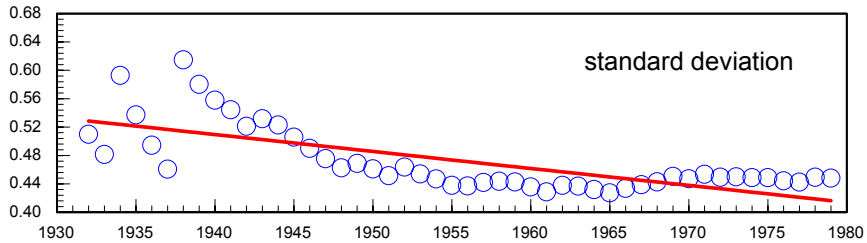
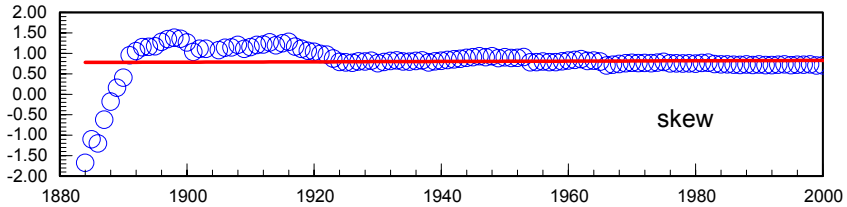
- Mountain Watershed STATIONARITY (Example) - Urbanizing Watershed

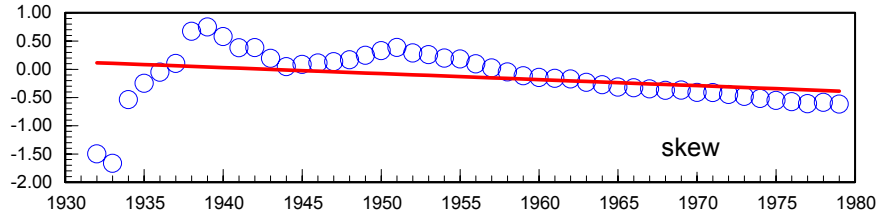


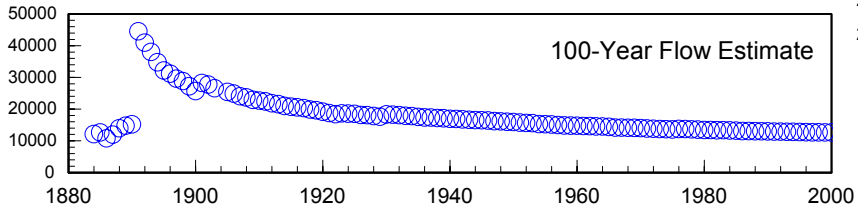


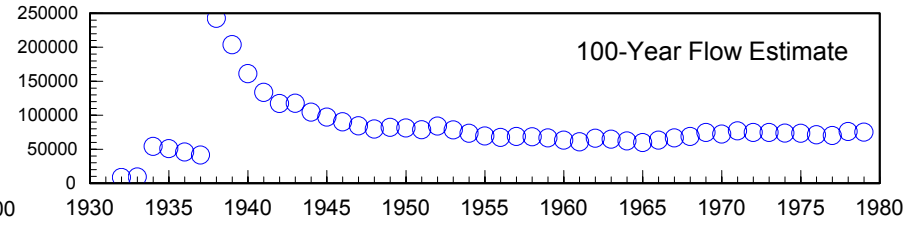












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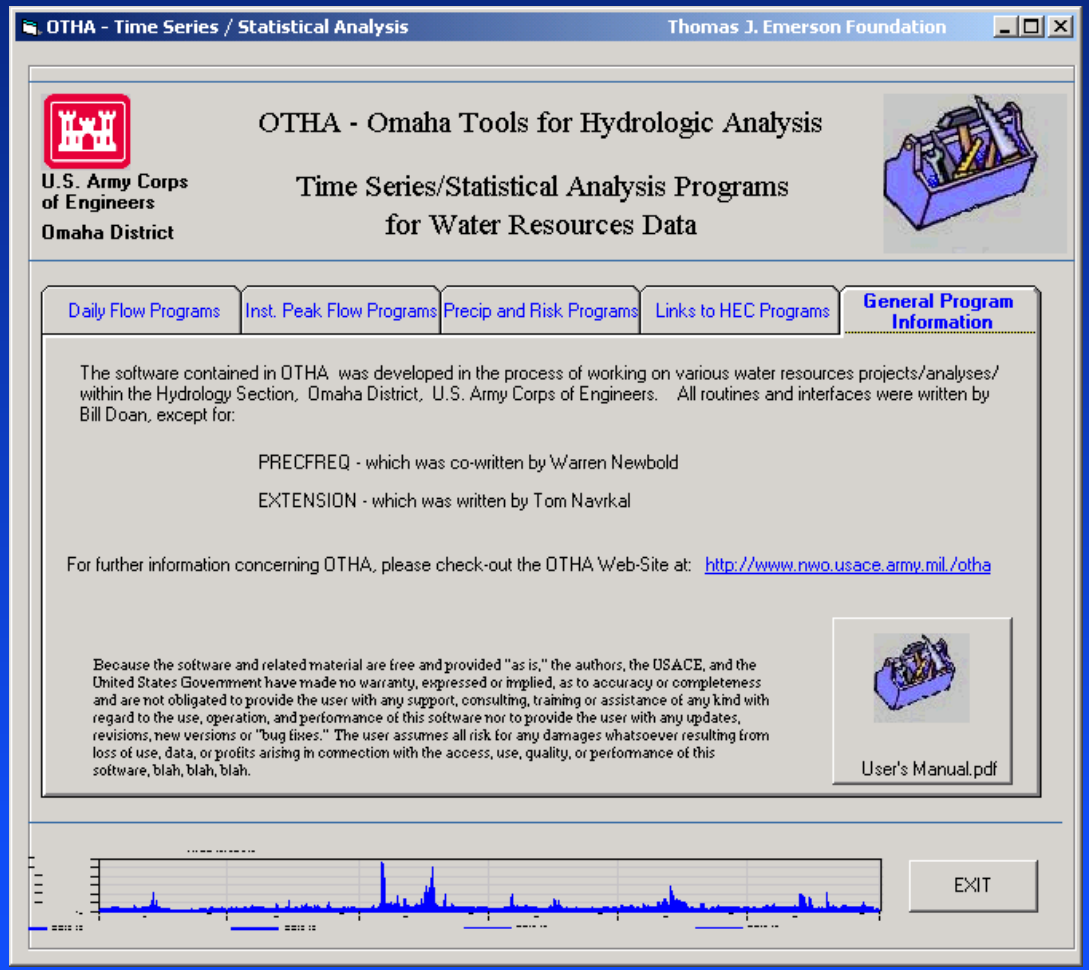
Conclusion



- Built-in Users Manual and link to Web-Site

- All routines have been used/tested in the Omaha District on a variety of projects

-All routines have built-in example files which are also the default values

-Written by/for Omaha District – available to whomever could use it

-For further information or downloads:

-*www.nwo.usace.army.mil/otha*

Questions?